A Novel Approach for the VLSI Implementation of Brain tumor Detection using PNN

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Abstract

Brain tumor is one in all the key causes of death among people. It is evident that the probabilities of survival are often accrued if the tumor is detected and classified properly at its early stage. Conventional strategies involve invasive techniques like biopsy, lumbar puncture or spinal tap method, to detect and classify brain tumors into benign (non cancerous) and malignant (cancerous). Digital thermal imaging is considered as a non-invasive diagnostic tool and a real-time monitoring technique for indicating the physiological changes of the underlying tissue from the superficial thermal signature. A thermal camera can detect temperature variations in the body, as low as 0.1°C. The observed color pattern depends on the prevailing temperature of the target in a controlled environment. Our proposed work, we given color-based thermal image and pattern is further processed for identifying abnormalities. This process of identification is done by applying various methods such as histogram equalization, Otsu thresholding and morphologic function. These steps are applied to thermal images of a brain tumor acquired from volunteers and abnormalities were identified. In this paper hardware implementation of segmentation of brain tumors will be carried out by using FPGA. It results in greater performance, less design and cost.

Keywords – Histogram, Thresholding, Morphological function, Brain and FPGA.

I. INTRODUCTION

Brain Tumor can simply be defined as Solid Intracranial Neoplasm. Intracranial means inside the cranium (i.e. The skull bone), Neo means new and Plasm means Growth. Brain tumors can be defined as a group of abnormal cells that grows inside or around brain, in other words, a brain tumor is an uncontrolled cells either located in one or more brain parts such as glial cells, neurons, lymphatic tissue, blood vessels, pituitary and pineal gland, skull, or spread from cancers mainly located in other organs. Brain tumors have been classified in following two types: i) Benign Tumors ii) Malignant Tumors.

Benign Tumors: A nonmalignant tumor could be a mass of cells (tumor) that lacks the ability to invade neighboring tissue or metastasise. These do not spread into, or invade, nearby tissues; however, they can sometimes be quite large. When removed, benign tumors usually do not grow back.

Malignant Tumors: A tumor that invades surrounding tissues is sometimes capable of producing metastasise, may recur after attempted removal, and is likely to cause death unless adequately treated.

A good classification process leads to the right decision and facilitates provision of good and appropriate treatment.

Treatments of Brain Tumor are determined by:

- Age of Patient
- Medical history
- Type of Tumor
- Location and
- Size of Tumor

Recently, it is possible to get information about the patient condition and to diagnose the disease using various imaging techniques without any medical operation. Brain Tumors are diagnosed clinically by the doctor based on symptoms which are confirmed by Biopsy, Human Inspection, Expert Opinion, Nerve Test and Radiological Examination (CT Scan and MRI).The biopsy method takes around ten to fifteen days of time for identification of the tumor. Human judgment may not always be correct and is prone to errors but a computer is not. In case of expert opinion, an expert might himself have to refer the case to another expert for an area-specific opinion. Tumors can affect the brain by destroying normal tissue, compressing normal tissue, or increasing intracranial pressure. Symptoms vary depending on the tumor's type, size, and location in the brain General symptoms include:

- headaches that tend to worsen in the morning
- stumbling, dizziness, difficulty walking
- speech problems (e.g., difficulty finding the right word)
- vision problems, abnormal eye movements

- weakness on one side of the body
- increased intracranial pressure, which causes drowsiness, headaches, nausea and vomiting, sluggish responses

This process continues for long time. In general, early stage brain tumor diagnosis mainly includes Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRl) scan, Nerve test and Biopsy. However, computer-aided diagnosis has been attracting more and more attention in recent times. Several techniques have been developed for feature extraction from MRI but wavelet transform is the best method of them . Wavelet Transform is a non statistical method which gives local frequency information and detail coefficients of the image at various levels. We have used Discrete Wavelet Transform (DWT) in our work. DWT gives good contrast to an image. Due to good contrast, Discrete Wavelet extracted very low signals of MRI. Principle component analysis (PCA) reduces the dimensions and overcomes the computational complexity. PCA has also been used for best feature extraction. For further classification, Probabilistic Neural Network (PNN) has been used.

II. METHODOLOGY

Brain cancer is one of the leading causes of death from cancer. There are two main types of brain cancer. They include primary brain cancer, in which the brain cancer originates in the brain itself. Primary brain cancer is the rarest type of brain cancer. It can spread and invade healthy tissues on the brain and spinal cord but rarely spreads to other parts of the body. Secondary brain cancer is more common and is caused by a cancer that has begun in another part of the body, such as lung cancer or breast cancer that spreads to the brain. MRI scan uses a magnetic field and radiofrequency waves to give a detailed view of the soft tissues of the brain. The Process flow of detecting tumor present in the brain. They are Image acquisition, Preprocessing, Median filter, Histogram equalization, Segmentation, Classification and FPGA Implementation.

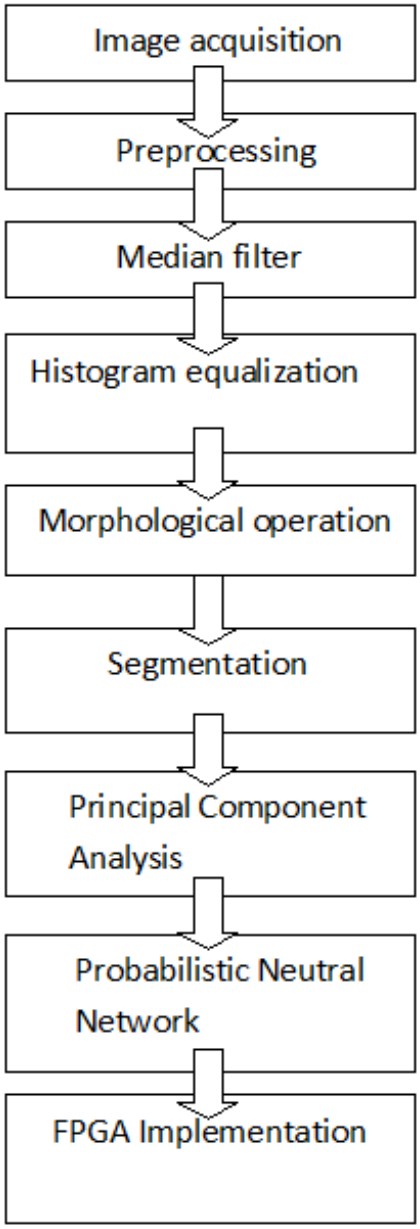


Fig: Flow Diagram

2.1 Image acquisition

In image processing, it is defined as the action of retrieving an image from some source, usually a hardware-based source for processing. It is the first step in the workflow sequence because, without an image, no processing is possible.

2.2 Preprocessing

RGB to grey image:

Grayscale is a range of monochromatic shades from black to white. Therefore, a grayscale image contains only shades of gray and no color. Many image editing programs allow you to convert a color image to black and white, or grayscale. This process removes all color information, leaving only the luminance of each pixel.

2.3 Median filter:

Median filtering is a nonlinear method used to remove noise from images. It is widely used as it is very effective at removing noise while preserving edges.

It is particularly effective at removing 'salt and pepper' type noise. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels.

2.4 Histogram Equalization

In this part we are only going to consider Gray scale images. As we have seen before, some images are really dark and have their histogram concentrated on the lower values of the intensity. So the objective of this part is to enhance the contrast of the image by equalizing the histogram. It improves contrast and obtains a uniform **histogram**. This technique can be used on a whole **image** or just on a part of an **image**.

2.5 Morphological Operation

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grayscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.

2.6 Adaptive Thresholding Segmentation

Adaptive thresholding typically takes a grayscale or color image as input and, in the simplest implementation, outputs a binary image representing the segmentation. For each pixel in the image, a threshold has to be calculated. If the pixel value is below the threshold it is set to the background value, otherwise it assumes the foreground value.

2.7 Principal Component Analysis

Principal component analysis (PCA) is one of the statistical techniques frequently used in signal processing to the data dimension reduction or to the data decorrelation. The use of artificial intelligent techniques for instant, neural networks, and fuzzy logic shown great potential in this field. Hence, the Probabilistic Neural Network was applied for the purposes. Decision making was performed in two stages: feature extraction using the principal component analysis and therefore the Probabilistic Neural Network (PNN).

2.8 Probabilistic Neural Network

In the classification classifiers senses the object properties or features such as energy, entropy, correlation, homogeneity entropy etc. We have seen various kinds of classifiers in past many years. Neural network classifiers are one of them. Neural networks are predictive models loosely based on the action of biological neurons. The Neural network (NN) is seen as information paradigm inspired by the way the human brain processes information. The selection of the name “neural network” was one of the great PR successes. It certainly sounds more exciting than a technical description such as “A network of weighted and additive values with nonlinear transfer functions”.

2.9 FPGA Implementation

The accuracy performances for both platforms are quite close, total computational time of the FPGA hardware platform is superior to MATLAB platform. Thus, segmentation of MR images on FPGAs can be successfully implemented in real-time. Because of the flexibility in design and reconfigurability of FPGAs, it has many advantages for designers both in terms of cost and implementation of new algorithms.

III. RESULT AND DISCUSSION

3.1 Image acquisition

The thermal image quality depends on controllable parameters such as ambient temperature, air flow and lighting. It is necessary to maintain the temperature at 21°C, without air draft and diffused lighting. The uncontrollable factors are patient metabolic rate and patient temperature. This can be indirectly controlled by ensuring the patient is duly rested and acclimatized to the screening environment. The thermal image can be improved further by enhancing the signal-to-noise ratio by ensuring that the patient does not apply a lotion/ cosmetics in the scanned region. Image acquisition is the process of retrieving the images from some sources. The brain tumor datasets are collected from Getty images and Shutter stock dataset.

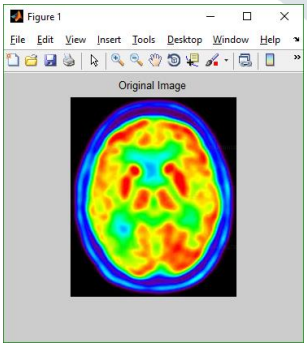
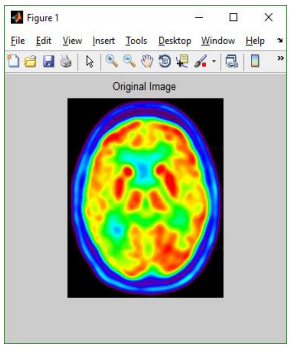


Fig: Sample input image

3.2 Preprocessing

RGB to grey image:

RGB is converted into grey scale Image, which is the intensity image. This conversion occurs by eliminating hue and saturation and retaining luminance.



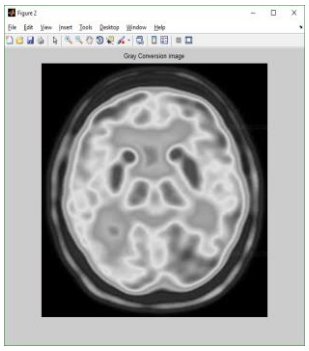


Fig: Input image

Fig: Preprocessing (RGB to Grey images)

In pre-processing, the RGB image is converted into Gray scale image. Gray scale image is white and black image and each pixel has only one value which is the intensity of the pixel.

3.3 Median filter:

Median filtering is a nonlinear method used to remove noise from MRI brain image. It is particularly effective at removing salt and pepper noise. Median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighboring pixels. The pixel is calculated by first sorting all the pixel values from the pattern of neighbors into numerical order, and then replacing the pixel being considered with median pixel value. Median filter is better able to remove noise without reducing the sharpness of the image.

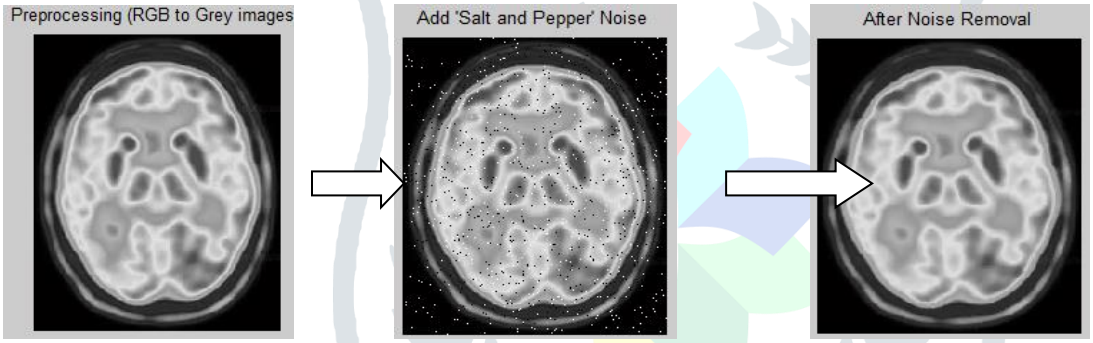


Fig: Pre-processing (RGB to Grey images)

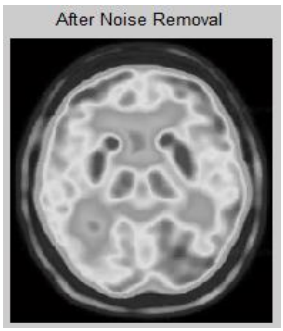
Salt and pepper Noise

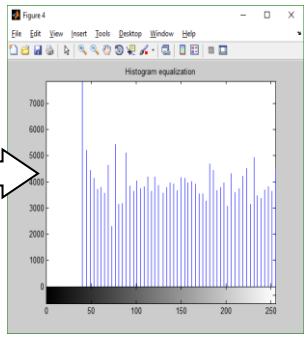
Fig: Median filtered image

3.4 Histogram Equalization

The Histogram of an image is a sequence of number of events of gray levels in the MRI image against the gray level qualities. The histogram provides suitable outline of the intensities in an image, yet it can't give any information regarding spatial relationships between pixels. The definition of Histogram Equalization is as **"Mapping of every pixel of input image into relating pixel of prepared output image is defined as Histogram"**. Histogram equalization can be done in three steps:

- Step1. Read or perused the input image (MRI images)
- Step2. Convert the input MRI image into Gray level MRI image.
- Step3. Apply or perform the Histogram Equalization procedure on the input image (MRI image) to enhance the contrast of the image.





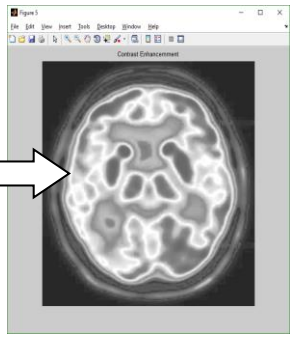


Fig: Median filtered image Fig: Histogram equalization Fig: Contrast enhancement

3.5 Morphological Operation

Dilation and Erosion

Morphology could be a broad set of image process operations that process pictures based on shapes. The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. Here are some properties of the fundamental binary morphological operators (dilation, erosion, opening and closing): they're translation invariant. They are increasing, that is, if, then, and, etc. The dilation is commutative.

Based on characteristics of its shape, which are encoded in the structuring element. Morphological Process in,

a. Original image
b. RGB to grey conversion
c. Dilation and erosion in the given image
d. Infected area is extracted from the original image

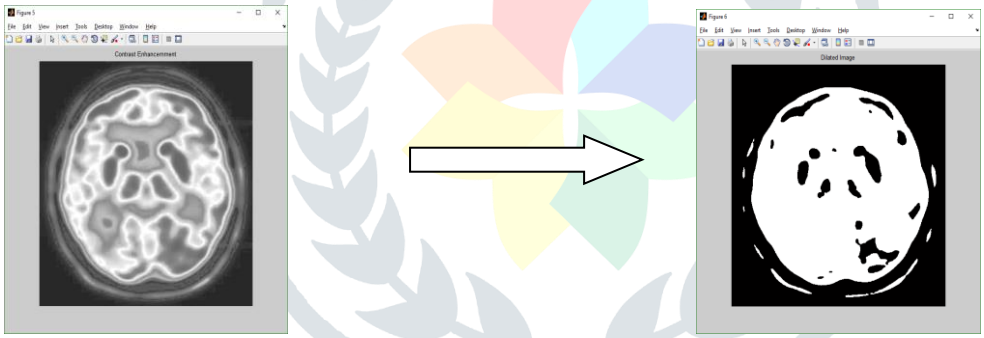


Fig: Contrast enhancement Fig: Dilated images

Erosion (usually represented by ⊖) is one amongst two basic operations (the other being dilation) in morphological image process from that all other morphological operations are based. It was originally outlined for binary images, later being extended to grayscale images, and subsequently to complete lattices.

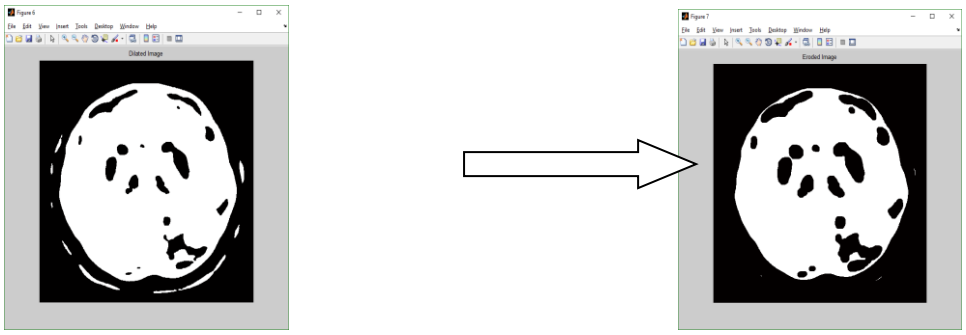


Fig: Dilated images Fig: Eroded images

3.6 Adaptive Thresholding Segmentation

Thresholding is used to segment an image by setting all pixels whose intensity values are above a threshold to a foreground value and all the remaining pixels to a background value. Whereas the conventional thresholding operator uses a global threshold for all pixels, adaptive thresholding changes the threshold dynamically over the image. This more sophisticated version of thresholding can accommodate changing lighting conditions in the image, *e.g.* those occurring as a result of a strong illumination gradient or shadows.

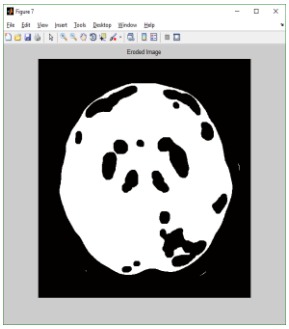


Fig: Eroded images

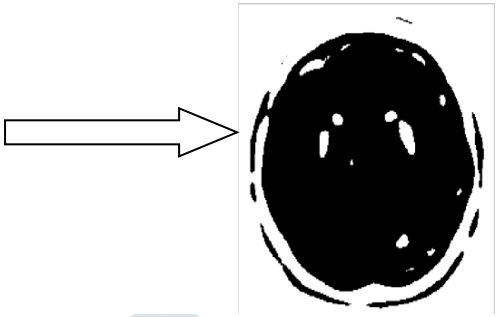


Fig: Adaptive thresholding segmented image.

If the pixel value is below the threshold it's set to the background value, otherwise it assumes the foreground value. Adaptive thresholding usually takes a grayscale or color image as input and, in the simplest implementation, outputs a binary image representing the segmentation. For each pixel within the image, a threshold has to be calculated.

3.7 Principal Component Analysis

This project classifies a brain tumor if it is a nonmalignant tumor or a malignant one. Probabilistic Neural Network offers fast and accurate classification and could be a promising tool for classification of the tumors.

3.8 Probabilistic Neural Network

Neural networks are predictive models loosely based on the action of biological neurons. The selection of the name "neural network" was one amongst the great PR successes of the Twentieth Century. It definitely sounds more exciting than a technical description such as "A network of weighted, additive values with nonlinear transfer functions". However, despite the name, neural networks are far from "thinking machines" or "artificial brains". A typical artificial neural network may need a hundred neurons. In comparison, the human nervous system is believed to have about 3x1010 neurons.

Fig: Adaptive Thresholding Segmented image

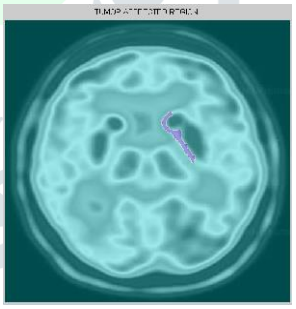


Fig: Tumor Affected region

This neural network like other probabilistic neural networks needs only a fraction of the training samples a back propagation neural network would need. The data available from measurements of an operating system is generally never enough for a back propagation neural network. Therefore the use of a probabilistic neural network is especially advantageous due to its ability to converge to the underlying function of the data with only few training samples available.

3.9 FPGA Implementation

The Basys2 board could be a circuit design and implementation platform that anyone will realize to gain experience building real digital circuits. Built around a Xilinx Spartan-3E Field Programmable Gate Array and an Atmel AT90USB2 USB controller, the Basys2 board provides complete, ready-to-use hardware suitable for hosting circuits ranging from basic logic devices to complex controllers. A large collection of on-board I/O devices and all required FPGA support circuits are included, so countless designs can be created without the need for any other components.

Four standard expansion connectors allow designs to grow beyond the Basys2 board using breadboards, user-designed circuit boards, or Pmods Signals on the 6-pin connectors are protected against ESD damage and short-circuits, ensuring a long operating life in any environment. Although accuracy performances for both platforms are quite close, total computational time of the FPGA

hardware platform is superior to MATLAB platform. Thus, segmentation of MR images on FPGAs can be successfully implemented in real-time. Because of the flexibility in design and reconfigurability of FPGAs, it has many advantages for designers both in terms of cost and implementation of new algorithms. The analysis is done with datasets of brain images. Each brain mage is taken separately and the results are observed using three methods such as Histogram equalization, Adaptive thresholding and Morphological operation. These method results are compared. Finally determined the accurate brain tumor region from sample brain images.

IV. CONCLUSION

Thermography can help to identify the stage of the disease by analyzing the picture which helps to start early treatment and prevent further damage. Three methods are used for the analysis of the brain tumor area. It was found that all three methods are useful. In so far as histogram method is concerned it helps in identifying a brain tumor. Adaptive segmentation methods help in extracting the region of interest by enhancing the tumor area.

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