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Analysis of Algorithms for Brain Tumor Segmentation

K. Vinulakshmi
PG Scholar, Department of Electronics and Communication Engineering,
Sri Eshwar College Of Engineering,
Coimbatore

M. Monica
PG Scholar, Department of Electronics and Communication Engineering,
Sri Eshwar College Of Engineering,
Coimbatore

L. Jubair Ahmed
Assistant Professor,
Department of Electronics and Communication Engineering,
Sri Eshwar College Of Engineering,
Coimbatore

***Abstract* -- The brain tumors are the mass of undifferentiated cells which form uncontrolled proliferation of cells in the brain. In this paper, I projected segmentation of brain tumor from Magnetic Resonance Images (MRI) using the Region Growing method to track tumor objects in brain images. The key concept in this technique is to separate the position of tumor objects exactly from other items of MR images. Region Growing is useful and simple method which uses several criteria to measure the characteristics of pixel and its neighborhood and also avoids characteristic segmentation errors. Several other algorithms have been proposed to segment brain tumor. Experiments show that the method can successfully achieve segmentation for MR brain images to help pathologists distinguish exactly lesion size and region.**

Keywords - Image Segmentation; Clustering; Region Growing

I. INTRODUCTION

BRAIN:

The brain is the portion of the central nervous system in vertebrates (animals with bones) that lies within the skull. In humans, the brain weighs about 3 pounds. The brain is a soft, spongy mass of *tissue*. It is protected by:

• The bones of the skull

• Three thin layers of tissue (*meninges*)

• Watery fluid (*cerebrospinal fluid*) within the brain

The human brain is an organ that controls an individual's ability to breathe, think, move and interact with the world around the individual. This organ consists of more than 15 billion cells used to receive, interpret and transmit information throughout the body.[3]

The brain is divided into three major parts, the hindbrain (including the cerebellum and the brain stem), the midbrain, and the forebrain (including the diencephalon and the cerebrum). This organ consists of more than 15 billion cells used to receive, interpret and transmit information a series of parts that each controls a different set of body functions.

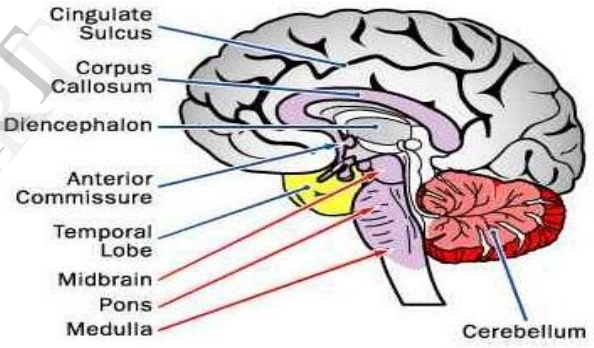


Fig.1.1 Major internal Parts of Human Brain

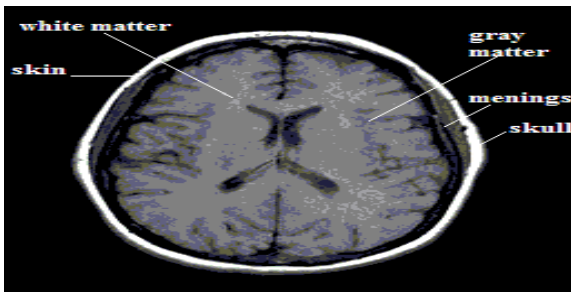


Fig.1.2 MR Image with internal parts

PARTS OF BRAIN:

- Brain stem

The brain stem is located at the lower end of the brain just in front of the cerebellum. This area regulates the body's blood pressure, temperature, breathing, digestion and heartbeat.

- Cerebellum

The cerebellum is located at the lower end of the brain in the area of the head between the ears. This part of the brain controls an individual's balance, muscle coordination and reflexes.

- Frontal Lobes

The frontal lobes are the section of the brain closest to the front of the head. These lobes control an individual's ability to concentrate, distinguish right from wrong, move, show emotions and speak.

- Occipital Lobe

The occipital lobes are the section of the brain closest to back of the head, which controls an individual's ability to see.

- Parietal Lobes

The parietal lobes are the section of the brain closest to top the head. This section controls an individual's hand - eye coordination and sense of touch.

II. TECHNIQUES FOR DIAGNOSING TUMOR

Some of the techniques to diagnose tumor by radiologists,

- A CT (computerized axial tomography) scan, which is a type of X-ray that builds up a two dimensional picture of the brain to show the position of tumor.[8]
- An MRI (magnetic resonance imaging) scan is a advanced technique uses magnetic fields, instead of X-rays, to build up a picture of the brain.
- An EEG (electroencephalogram), which is a painless test that records the electrical activity of the brain.
- An X-ray of the blood vessels (angiogram) to show the position of the tumor.
- A biopsy, where a small tissue sample is removed during surgery. The sample is examined in the laboratory to find out what type of tumor it is and how fast it is growing.

III. MAGNETIC RESONANCE IMAGING

Nuclear Magnetic resonance (NMR) has recently emerged as a powerful imaging technique in the medical field, because of its high resolution capability and potential for chemical specified imaging. It uses magnetic fields and radio frequency signals to obtain NMR images are essentially map of the distribution density of hydrogen nuclei and parameter reflecting their motion, in cellular water and lipids.

All materials contain nuclei that are either proton or neutron or either combination of both, a nuclear spin and magnetic moment which has both magnitude and direction.[1]. When a material is placed in a magnetic field B0 sum of the randomly oriented nuclei experience torque to align the individual parallel or anti-parallel magnetic moments to the direction of an applied magnetic field, then gives the tissue a net magnetic moment.

$$E=hU0$$

H=plank's constant divided by 2D.

When the nucleus with a magnetic moment is placed in a magnetic field, the energy of the nucleus is split into lower (moment parallel with a field) and higher (anti-parallel) energy levels; the energy difference is such a proton with specific frequency (energy) is necessary to excite a nucleus from lower to higher state.

IV. IMAGE PROCESSING

Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goal of this manipulation can be divided into three categories.[1]

- Image processing: image in-> low-level image out
- Image analysis: image in-> measurements out
- Image understandings: image in-> high-level description out

Steps involved in image processing,

- Image Acquisition
- Image Enhancement
- Image Restoration
- Compression
- Segmentation
- Object Recognition

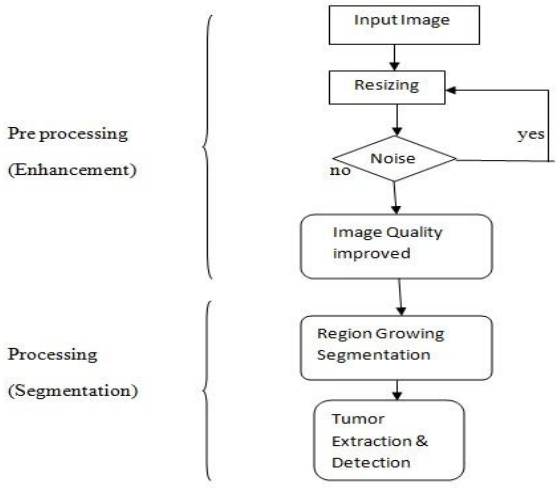


Fig.4.1 Flow Process

Image Acquisition**:**

Image acquisition is the first step involved in image processing. This involves pre-processing such as scaling. This mainly involves squiring an image. An image can be acquired with the help of any equipment.

Image Enhancement**:**

Image enhancement is among the simplest and most appealing areas of digital image processing. Basically, the idea behind enhancement techniques is to bring out details that are obscured, or to highlight features of interest of an image. Image enhancement is a subjective area.

Compression**:**

Compression deals with the techniques for reducing the image required for saving an image, or the bandwidth required to transmit it. Image compression is familiar to most users of computers in the form of image file extensions, such as the jpeg file extension used in the JPEG image compression standard.[

Image Restoration**:**

Image restoration is the area that deals with improving appearance of an image. Image restoration is an objective area. It is based on mathematical or probabilistic models of image degradation.

Segmentation:

Segmentation procedures partition an image into its constituent parts or objects. The more accurate the segmentation, the more likely region or all the points in the region itself.

- Medical Imaging
  - Locate tumors and other pathologies
  - Measure tissue volumes
  - Computer – guided surgery
  - Diagnosis
  - Treatment planning
  - Study of anatomical structure
  - Locate objects in satellite images (roads, forests, etc.)
- Face recognition
- Fingerprint recognition
- Automatic traffic controlling systems
- Machine vision

Recognition**:**

Image segmentation is typically used to locate objects in images. The result of image segmentation is a set of regions that collectively cover the entire image. Each of the pixels in the region is similar with respect to some characteristic such as color, intensity, or texture. Recognition is the process that assigns a label to an object based on its descriptors.

V .COLOR SPACE TRANSFORMATION

Pseudo Color Translation:

Original MR brain image is a gray-level image insufficient to support fine features. To obtain more useful features and enhance the visual density, the proposed method applies pseudo-color transformation, a mapping function that maps a gray-level pixel to a color-level pixel by a lookup table in a predefined color map. An RGB color gradually maps gray-level values 0 to 255 into blue-to-green-to-red color. This map contains R, G, and B values for each item. Each gray value maps to an RGB item.[2]

The RGB color model is an additive color model in which red, green, and blue light are added together. RGB uses additive color mixing and is the basic color model used in television or any other medium that projects color with light. It is the basic color model used n computers and for web graphics, but it cannot be used for print production. RGB is easy to implement but non– linear with visual perception. The secondary colors of RGB – cyan, magenta, and yellow – are formed by mixing two of the primary colors (red, green or blue) and excluding the third color. Red and green combine to make yellow, green and blue to make cyan, and blue and red form magenta. The combination of red, green, and blue in full intensity makes white.

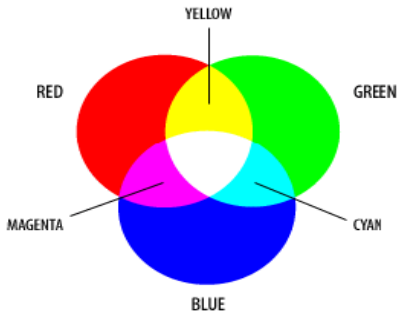


Figure.5.1 The additive model of RGB

- ✓ **Brightness:** the human sensation by which an area exhibits more or less light.
- ✓ **Hue**: the human sensation according to which an area appears to be similar or proportions of two, of the perceived colors red, yellow, green and blue.
- ✓ **Colorfulness**: the human sensation according to which an area appears to exhibit more or less of its hue.
- ✓ **Lightness**: the sensation of an area's brightness relative to a reference white in the scene.
- ✓ **Chroma:** the colorfulness of an area relative to the brightness of a reference white.
- ✓ **Saturation**: the colorfulness of an area relative to its brightness**.**

VI. TYPES OF IMAGE SEGMENTATION

Some types of segmentation:

- Cluster method
- Histogram based methods
- Edge detection methods
- Region growing method

CLUSTERING METHODS

The K-means algorithm is an iterative technique that is used to partition an image into K clusters. The basic algorithm is:

1. Pick K cluster centers, either randomly or based on some heuristic.
2. Assign each pixel in the image to the cluster that minimizes the variance between the pixel and the cluster center.
3. Re-compute the cluster centers by averaging all of the pixels in the cluster.
4. Repeat steps 2 and 3 until convergence is attained.

REGION GROWING METHODS:

The first region growing method was the seeded region growing method. This method takes a set of seeds as input along with the image. The seeds mark each of the objects to be segmented. The difference between a pixel's intensity value and the region's mean, λ is used as a measure of similarity. The pixel with the smallest difference measured this way is allocated to the respectively region. This process continues until all pixels are allocated to region. [4]

One variant of this technique is based on pixel intensities. The mean and scatter of the region and the intensity of the candidate pixel is used to compute a test statistic. Otherwise, the pixel is rejected, and is used to form a new region.

HISTOGRAM-BASED METHODS:

Histogram –based methods are very efficient when compared to other image segmentation methods because they typically require only one pass thought the pixels. In this technique, a histogram is computed from all of the pixels in the image, and the peaks and valleys in the histogram are used to locate the clusters in the image. Color or intensity can be used as the measure.

EDGE DETECTION METHODS:

Edge detection is a well-developed field on its own within image processing. Region boundaries and edges are closely related, since there is often a sharp adjustment in the region boundaries. Edge detection techniques have therefore been used to as the base of another segmentation technique. The edges identified by edge detection are often disconnected. To segment an object from an image however, one needs closed region boundaries. Discontinuities are bridged if the distance between the two edges is within some predetermined threshold.[7]

VII. CLUSTERING ALGORITHIMS

- K-means Algorithm
- Region Growing Clustering
- Fuzzy C-means Clustering
- Bee Algorithm
- Genetic Algorithm

The input to the system is the MRI gray scale image. The input to the other clustering algorithms is the image after Pseudo Color Translation and Color Space Translation.

K-MEANS CLUSTERING ALGORITHM:

The initial partitions are chosen by getting the R, G, B values of the pixels. Every pixel in the input image is compared against the initial partitions using the Euclidian Distance and the nearest partition is chosen and recorded.[2]

The mean in terms of RGB color of all pixels within a given partition is determined. This mean is then used as the new value for the given partition. Once the new partition values have been determined, the algorithm returns to assigning each pixel to the nearest partition. The algorithm continues until pixels are no longer changing which partition they are associated with or until none of the partition values changes by more than a set small amount.

1. The whole image is in one cluster.
2. Find the most dissimilar point in the image and divide the image into two clusters.

Repeat step2 for each cluster.

REGION GROWING CLUSTERING:

It is a region based segmentation method. This process is first requirement of manually select seed points. Selection of seed points is based on user criteria. It is also iteration based method, like clustering algorithms.

The algorithm steps for region growing technique are below:

1. In the first step manually select seed points.
2. In the next steps pixels in the region of seeds are examined and added to the region accordance with the homogeneity criteria. This process is continued until all pixels belong to some region.
3. Repeat step 2 for each of the newly added pixels; stop if no more pixels can be added.
4. In last step the object illustration is done by growing regions of pixels.

(8 neighbors, predicate:$|z - zseed| < 0.1(\max z - \min z)$)

The region growing technique applied in medical image segmentation. In medical field, it can be applied in kidney segmentation, extraction of brain surface, cardiac images etc. the main disadvantage of this method is, it require user interface for selection of seed points Thus for each region that selection of seed is require user interface and very time consuming process.[6]

FUZZY C-MEANS CLUSTERING:

The Fuzzy C-Means algorithm (often abbreviated to FCM) is an iterative algorithm that finds clusters in data and which uses the concept of fuzzy membership; instead of assigning a pixel to a single cluster, each pixel will have different membership values on each cluster.[5]

The Fuzzy C-Means attempts to find clusters in the data by minimizing an objective function shown in the equation below:

$$J = \sum_{i=1}^{N} \sum_{j=1}^{C} \mu_{ij}^{m} \left| x_i - c_j \right|^2$$

J is the objective function.
After one iteration of the algorithm the value of *J* is smaller than before.
It means the algorithm is converging or getting closer to a good separation of pixels into clusters.
N is the number of pixels in the image.
C is the number of clusters used in the algorithm, and which must be decided before execution.
μ is the membership table -- a table of *N*x*C* entries which contains the membership values of each data point and each cluster.
m is a fuzziness factor (a value larger than 1).
Xi is the *ith* pixel in *N*.
Cj is *jth* cluster in *C*.
|*xi* - *cj*| is the Euclidean distance between *xi* and *cj*.

BEE ALGORITHM:

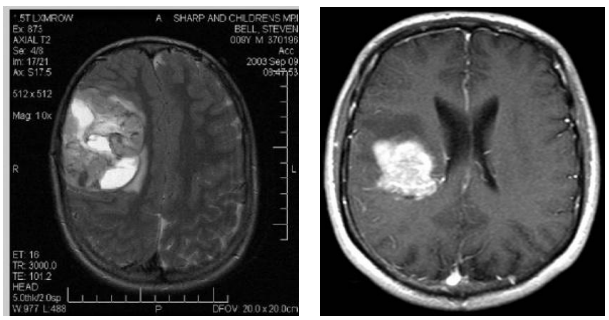
The bee algorithm is an optimization algorithm inspired by the natural foraging behavior of honey bees to find the optimal solution.[8] The algorithm requires a number of parameters to be set, namely: number of scout bees (n), number of sites selected out of n visited sites (m),number of best sites out of m selected sites (e), number of bees recruited for the other (m-e) selected sites (n1), number of bees recruited for best e sites (n2), initial size of patches (ngh) which includes site and its neighborhood .The algorithm starts with the n scout bees being placed randomly in the search space.[3]

Employed and onlooker bees explore new food sources in the neighborhood of current food sources. Onlooker bees start exploration process after the employed bees completed their process. The difference between the employed and onlooker bees on the way of applying the exploration process is that onlooker bees tend to search in the neighborhood of the food sources owning more nectar, but employed bees search in the neighborhood of their associated food sources. After the completion of the exploration process, scout bees control whether there is an exploited (abandoned) food source.

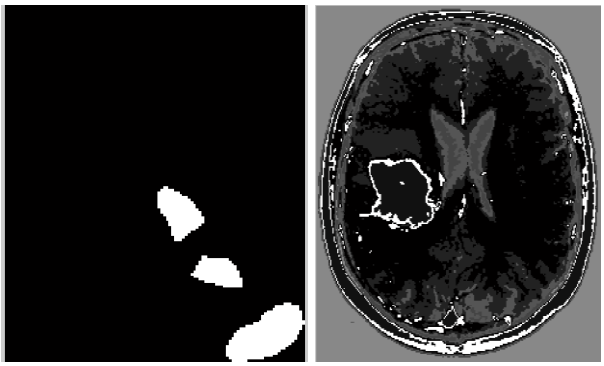
GENETIC ALGORITHM:

Genetic algorithm (GA) propose in 1975 is based on natural selection and evolution. In GA, each individual known as chromosome represents a solution of the handled problem. A chromosome comprises bit strings called as genes. The main purpose is to evolve chromosomes through crossover and mutation operators. To evolve chromosomes, new generation, called offspring, are generated by merging two chromosomes using a crossover operator and by modifying bit string of a chromosome using a mutation operator. In this way, the crossover operator satisfies cooperation and the mutation operator satisfies diversity in population. Then, new population is selected from the current and generated chromosomes according to their fitness values.

VIII. EXPERIMENTAL RESULTS



(a)



(b)

Fig.8.1 segmented (a) Input and (b) Output Images by using Region Growing and K-Means method respectively.

IX. CONCLUSION

The system is employed by a method of segmentation for brain tumor from Magnetic Resonance Images (MRI) and to detect the abnormalities using the Region Growing method to track tumor objects in brain images. Segmentation process becomes semiautomatic starting with an interactive seed point selection step, followed by the region growing process which is a simple method which avoids characteristic segmentation errors. By using segmenting method, good results are obtained, which does not suffer the weaknesses of manual segmenting operator errors. The results help the physicians to diagnose the abnormalities or tumors more efficient in a suitable time. Several other algorithmic techniques have been analyzed to segment brain tumor from MR images.

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