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An implementation of random walk algorithm to detect brain cancer in 2-d MRI

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Abstract— Brain is the control unit of a human body and is a highly specialized organ. It controls all the body functions. There are many diseases that could affect the normal functioning of brain and one of them is brain cancer. Some kinds of tumors are the prime cause of brain cancer. A brain tumor takes up space within the skull and can interfere with normal brain activity. It can increase pressure in the brain, shift the brain or push it against the skull, and/or invade and damage nerves and healthy brain tissue. Here random walk method is used to segment brain tissues for detection of cancerous cells.

***Index Terms*— MRI, Tumor, Image Segmentation, Random Walk.**

I. INTRODUCTION

Brain cancer is a serious form of cancer that occurs when there is an uncontrolled growth of cancer cells that form a malignant tumor in the brain. Brain cancer occurs when there is an uncontrolled growth of cancer cells in the brain that form a malignant brain tumor. The underlying cause of primary brain cancer, cancer that begins in the brain, is not known. Secondary brain cancer is caused by a cancer of another organ in the body, such as the breast, prostate, kidney, skin, or bone that has spread to the brain

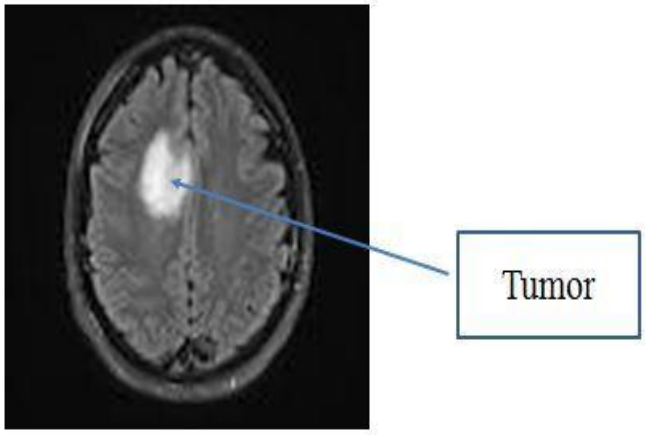
A **brain tumor** is defined as an *abnormal growth of cells* within the brain.

Brain tumors include all tumors inside the cranium or in the central spinal canal. They are created by an abnormal and uncontrolled cell division, usually in the brain itself, but also in lymphatic tissue, in blood vessels, in the cranial nerves, in the brain envelopes (meninges), skull, pituitary gland, or pineal gland.Within the brain itself, the involved cells may be neurons or glial cells (which include astrocytes, oligodendrocytes, ependymal cells, and myelin-producing Schwann cells). Brain tumors could also spread from cancers primarily located in other organs.Any brain tumor is inherently serious and life-threatening because of its invasive and infiltrative character in the limited space of the intracranial cavity. However, brain tumors (even malignant ones) are not invariably fatal, especially lipomas which are inherently benign. Brain tumors or intracranial neoplasms can be cancerous (malignant) or non-cancerous (benign); however, the definitions of malignant or benign tumors differ from those commonly used in other types of cancerous or non-canceroustumors in the body. Its threat level depends on the combination of factors like the type of tumor, its location, its size and its state of development. Because the brain is well protected by the skull, the early detection of a brain tumor only occurs when diagnostic tools are directed at the intracranial cavity. Usually detection occurs in advanced stages when the presence of the tumor has caused unexplained symptoms.

Brain cancer begins at the microscopic cellular level, the first signs of a malignant (actively cancerous) growth are nearly impossible to detect without special tests and training. As the tumor becomes more organized, new blood vessels may form to feed it directly or older vessels may be diverted. Meanwhile, the host body may only experience a few symptoms which resemble many other conditions besides cancer.

Brain cancer detection is a multi-staged process. In order to reduce erroneous results due to misclassification, skull removal is the primary step in the process of brain cancer detection. This leads to the removal of nonbearing tissues and only soft brain tissues are left. This is followed by tumor segmentation and then application of random walk method.

Figure 1Diagram illustrating tumor



Magnetic resonance imaging is a relatively new technology first developed at the University of Aberdeen, UK. Magnetic resonance imaging is a medical imaging technique used in radiology to imagine better understanding of interior structures. MRI makes use of the property of nuclear magnetic resonance (NMR) to illustrate nucleus of atoms inside the body.MRI provides good contrast between the different soft tissues of the body, which makes it especially useful in imaging the brain, muscles, the heart, and cancers compared with other medical imaging techniques such as computed tomography (CT) or X-rays. One advantage of an MRI scan is that it is harmless to the patient. Actually other imaging technique like CT scans or traditional X-rays makes use of the ionizing radiation but MRI is free from it.

In this work brain cancer tissues are taken into the observation. It uses strong magnetic fields and non-ionizing radiation in the radio frequency range, unlike CT scans and traditional X-rays, which both use ionizing radiation. While CT has the quality to distinguish two separate structures an arbitrarily small distance from each other i.e. it provides good spatial resolution but MRI has the quality to distinguish the differences between two arbitrarily similar but not identical tissues comparable resolution with far better contrast resolution. The basis of this ability is due to the complex library of pulse sequences that the modern medical MRI scanner includes, each of which is optimized to provide image contrast based on the chemical sensitivity of MRI. There are two types of basic MRI scan (a) T1-weighted MRI (b) T2-weighted MRI. These two types of images are formed due to the property of the pulse generation sequence and these pulses controls the activity of providing better contrast between inter structural parts of the brain i.e. the pulses can be inverted to perform reverse operation while scanning the part of the body

T1 weighted MRI: This is a basic standard scan which provides well contrast between fat and water. In this MRI the water is represented by the darker portion and the fat portion is represented by the brighter intensity values. While forming this image the gradient echo sequence with small values of the echo time and repetition time. Due to the small repetition time scanning process becomes very fast in this imaging technique.

T2 weighted MRI: This is just opposite to the T1 weighted MRI. In this imaging technique fat portion of the brain is represented by the darker parts and water part is shown by the brighter intensity values. Also echo time and repetition time are long.

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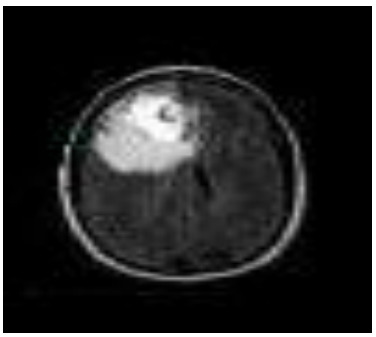

FIGURE 2 MAGNETIC RESONANCE IMAGE

Magnetic resonance imaging (MRI) of the brain is a safe and painless test that uses a magnetic field and radio waves to produce detailed images of the brain and the brain stem. An MRI doesn't use radiation, which is one way it differs from a CAT scan (also called a CT scan or a computed axial tomography scan).

II. METHODOLOGY

This proposed work has been divided into three parts-skull removal, seed point selection and random walk. The diagram shown below illustrates the sequence of tasks to be performed in brain cancer detection.

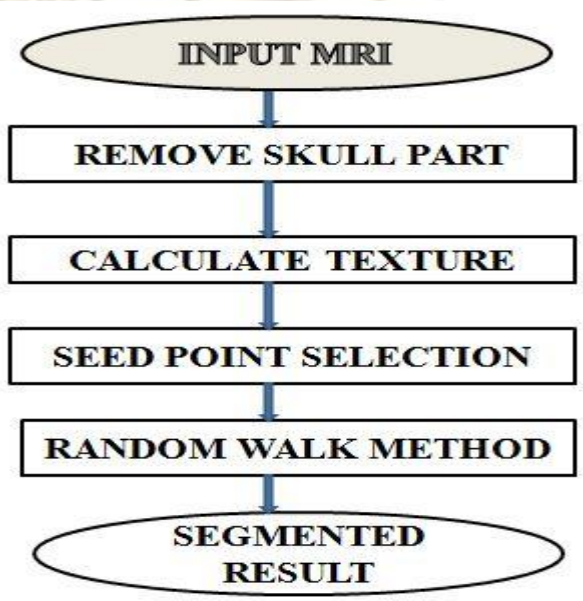

Figure 3 WORK FLOW GRAPH

A. Skull removal process

Skull removal is a major phase in MRI brain imaging applications and it refers to the removal of the brain's non-cerebral tissues. Skull removal has been one of the key pre-processing phases in brain imaging applications [1] and for further analysis of Magnetic Resonance Imaging (MRI) brain images [2]. The main problem in

skull-stripping is the segmentation of the non-cerebral and the intracranial tissues due to their homogeneity intensities. This is a preprocessing stage for proposed methodology. We have observed that intensity value for the skull part is generally greater than eighty. For removal of the skull part all pixels intensities are set to zero. Skull is unused part in the image for abnormality detection. This is not comprised of any soft tissues so cancerous cells i.e. tumors are not present. Skull removal process avoids the chances of erroneous results in seed point selection.

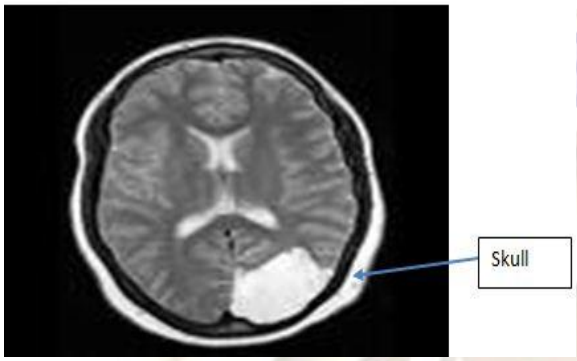

Figure 4 Skull part in MRI

The following algorithm is designed for skull removal:

(a) First of all find the size of the image and store the no of rows and columns in separate variables.

(b) Perform iteration for half of the columns and all rows.

(c) Process half of image to convert white pixels into the black pixels by setting their gray values to zero.

(d)Same steps are repeated for the remaining columns and rows.

B. Seed point selection

The image obtained after skull removal is taken as input in this part of the project. Positioning of the seed across the input image gives many possible sub-segmentations of the image having same texture and color property as the pixels i.e. evaluation parameters the seed. Seed point selection has a vital role in the identification of abnormality in the brain image i.e. segmentation is completely dependent on seed point selection. The assumption for this stage is that tumor has grown in considerable size. For the seed point selection we have strengthen our method by combining two approaches described in the algorithm. For the texture analysis of the image mean of the all gray levels are taken so that presence of abnormality can be determined in the input image.

C. Random walk method

The evaluation parameters of image acquisition are echo time (TE) and repetition time (TR).**Random walk is defined as discrete random motion in which a particle repeatedly moves a fixed distance up, down, east, west, north or south.** This is also a region growing based image segmentation method based on random walk of a particle. In this method the initial position at which a particle is initially present is known as seed point. After calculation of the seed point from second stage this stage starts from the seed point. The region is grown until the result is obtained. Movement from one position to another is based on the probability calculation. It can be explained with following mathematical expression.

Lehmer also invented the *multiplicative congruential algorithm*, which is the basis for many of the random number generators in use today. Lehmer's generators involve three integer parameters, *a*, *c*, and *m*, and an initial value, *x*0, called the *seed*. A sequence of integers is defined by

$$x_{k+1} = ax_k + c \bmod m$$

The operation "mod m" refers to the remainder obtained after division by m.

Consider a random walk on an edge-weighted directed graph G = (V;E) with a weighting function on the set of edges w :

Denote by wij the nonnegative weight of the directed edge ij between nodes i and j.

If ij =2 E, then wij = 0.

Random walk may be viewed as a process of sequential vertex and can be denoted as the given function:-

[W,Ew,Wbsf,Ebsf,Ea,Ev] = randomwalk(steps, walkers, newstate, X, cost, moveclass)

steps = the number of random steps to talk

walkers = number of walkers. Must be positive integer.

newstate = (handle to) user-defined method

X = user-defined problem domain or other data, behaviorally static.

Cost = (handle to) user-defined objective method (function)

Ew = cost(X,W) where

X = user-defined problem domain or other data.

W = a user-defined state from 'newstate' or 'moveclass'.

moveclass = (handle to) user-defined method,

W = moveclass(X,W,Ea,T) where

X = user-defined problem domain or other data.

W = a user-defined state from 'newstate' or 'moveclass'.

Ea = average energy at current temperature.

T = current temperature (will be infinite in Tinit)

OUTPUTS:

W = cell array of user-defined state(s) from 'newstate' or 'moveclass'.

Ew = current energies corresponding to W (size walkers)

Ev = energy (cost) history at T (T is Inf in random walk)

i = arbitrary index

Ev(i,1) = step #

Ev(i,2) = walker #

Ev(i,3) = an energy visited during T

Ev(i,4) = energy attempted from Ev(i,1:3) during T

Wbsf = cell array of best-so-far states of size 'walkers'
Ebsf = array of best-so-far energies
Ea = average energy

III.RESULTS

Firstly the MRI data is taken as input. The input data is visualized in figure 5. This input image is preprocessed to remove the outer part of the brain known as skull because this may affect the seed point calculation result. The figure 6 shows the result of preprocessing of actual MRI. After the seed point has been detected, random walk method is to be performed for segmentation and then the final segmented result is displayed in figure 7.

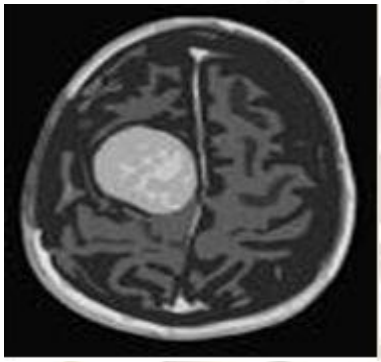

Fig 5 Input Brain MRI

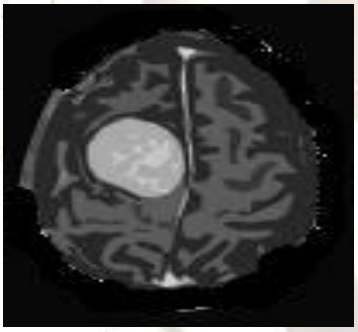

Fig6 After skull removal

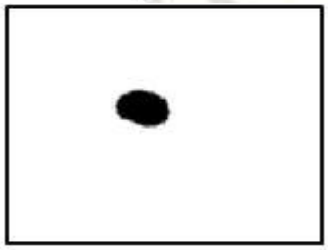

Fig7 after Random walk

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