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Controller General of Patents,Designs and Trademarks
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Application Details	
APPLICATION NUMBER	202041052252
APPLICATION TYPE	ORDINARY APPLICATION
DATE OF FILING	01/12/2020
APPLICANT NAME	**DR. A. RAMASWAMI REDDY**
TITLE OF INVENTION	AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES
FIELD OF INVENTION	COMPUTER SCIENCE
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E-MAIL (UPDATED Online)	
PRIORITY DATE	
REQUEST FOR EXAMINATION DATE	--
PUBLICATION DATE (U/S 11A)	11/12/2020

Application Status	
APPLICATION STATUS	**Awaiting Request for Examination**

View Documents

➡ Filed ➡ Published ➡ RQ Filed ➡ Under Examination

➡ Disposed

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CHALLAN : TR-5
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To,
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Agent Number:

Sr. No.	CBR No.	Reference Number /Application Type	Application Number	Title/Remarks	Amount Paid
1	40476	ORDINARY APPLICATION	202041052252	AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES	1750
2		E-2/3526/2020-CHE	202041052252	Form2	0
3		E-3/36504/2020-CHE	202041052252	Form3	0
4		E-5/3338/2020-CHE	202041052252	Form5	0
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(19) INDIA

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(54) Title of the invention : AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES

(51) International classification	:G06T 7/00
(31) Priority Document No	:NA
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Filing Date	:NA
(62) Divisional to Application Number	:NA
Filing Date	:NA

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(57) Abstract :

ABSTRACT AN-EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES Image segmentation with a focus on Magnetic Resonance (MR) images of brain has become very essential in diagnosis of abnormality in the brain. Identification of gray scale values of brain tissues is complex in nature because inhomogeniety. Identifying brain disorders deeply depend upon perfect segmentation of three brain tissues namely Gerebro-Spinal Fluid (CSF), White Matter (WM) and-Gray Matter {GM) of MR image. The segmentation methods addressed in the literature could neither able to yield the labeling nor identify the boundaries of an image to locate the tumor and effected area. In this work, initially, the brain MR image segmentation has been performed by using statistical and stochastic models such as Histogram thresholding, Region Growing method, K-means method and Expectation Maximization (EM) algorithm to identify tumor with and without noise in brain MRI. These are simple threshold, distance based segmentation techniques and do not consider spatial information while processing, which is an important parameter in the image segmentation. Finally, Hidden Markov Random Field (HMRF) model developed, in this model, the systems believe a Markov process with latent or hidden states and the dependence of the output on the state is noticeable, sven though the state is hidden. The results obtained from Hidden Markov Random Field mode! are compared with Fuzzy- MRF model. Finally, it is observed that the segmentation results obtained from HMRF model are more accurate in terms of quality metrics more effective in dealing images in a noise environment

No. of Pages : 15 No. of Claims : 7

“FORM 1 THE PATENTS ACT 1970 (39 of 1970) and THE PATENTS RULES, 2003 **APPLICATION FOR GRANT OF PATENT** (See section 7, 54 and 135 and sub-rule (1) of rule 20	(FOR OFFICE USE ONLY)
Application No.	
Filing date:	
Amount of Fee paid:	
CBR No:	
Signature:	

1. APPLICANT’S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)	

2. TYPE OF APPLICATION [Please tick ( ) at the appropriate category

Ordinary (√)		Convention (x)	PCT-NP (x)		
Divisional **(√)**	Patent of Addition ( )	Division ( )	Patent of addition ()	Division ( )	Patent of Addition ( )

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Are all the inventor(s) same as the applicant(s) named above?	Yes ()	**No (√)**

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5. TITLE OF THE INVENTION

AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES

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8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION

Country	Application Number	Filing date	Name of the applicant	Title of the invention	IPC (as classified in the convention country)
NA	NA	NA	NA	NA	NA

9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)

International application number	International filing date
NA	**NA**

10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION

Original (first) application No.	Date of filing of original (first) application
NA	NA

11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT : NA

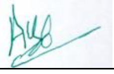
Main application/patent No. : **NA**	Date of filing of main application : **NA**

12. DECLARATIONS

(i) Declaration by the inventor(s)

(In case the applicant is an assignee: the inventor(s) may sign herein below or the applicant may upload the assignment or enclose the assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period).

We, the above named inventor(s) are the true & first inventor(s) for this Invention and declare that the applicant(s) herein are our assignee or legal representative.

Name of the signatory	Signature	Date
Dr. A. Ramaswami Reddy		01.12.2020

(ii) Declaration by the applicant(s) in the convention country

(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)

We, the applicant(s) in the convention country declare that the applicant(s) herein are our assignee or legal representative.

(a) Date
(b) Signature(s) -------NA----------
(c) Name(s) of the signatory

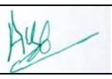
(iii) Declaration by the applicant(s)

- We the applicant(s) hereby declare(s) that: -
- We are in possession of the above-mentioned invention.
- The complete specification relating to the invention is filed with this application.
- ~~The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.~~
- There is no lawful ground of objection(s) to the grant of the Patent to me/us.
- We are the true & first inventor(s).
- We are the assignee or legal representative of true & first inventor(s).
- ~~The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of our invention(s).~~
- ~~We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which I/We derive the title.~~
- ~~Our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.~~
- ~~The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.~~
- ~~The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.~~
-

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION (a) Form 2

Item	Details	Fee	Remarks
Complete specification	No. of pages : 15		
No. of Claim(s)	No. of claims : 07 and No. of pages : 01		
Abstract	No. of pages :01		
No. of Drawing(s)	No. of drawings :-- and No. of pages:--		

~~# In case of a complete specification, if the applicant desires to adopt the drawings filed with his provisional specification as the drawings or part of the drawings for the complete specification under rule 13(4), the number of such pages filed with the provisional specification are required to be mentioned here. (b) Complete specification (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).~~
~~(c) Sequence listing in electronic form~~
~~(d) Drawings (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).~~
~~(e) Priority document(s) or a request to retrieve the priority document(s) from DAS (Digital Access Service) if the applicant had already requested the office of first filing to make the priority document(s) available to DAS.~~
~~(f) Translation of priority document/Specification/International Search Report/InternationalPreliminary Report on Patentability.~~
(g) Statement and Undertaking on Form 3
(h) Declaration of Inventorship on Form 5
(j)……………………………………………………………………………………………….
Total fee
We hereby declare that to the best of our knowledge, information and belief the fact and matters slated herein are correct and We request that a patent may be granted to us for the said invention.

Name of the signatory	**Signature**	**Date**
Dr. A. Ramaswami Reddy		01.12.2020

To,
The Controller of Patents The Patent Office, at **CHENNAI**

Form 2

THE PATENT ACT, 1970

(39 of 1970)

&

The Patent Rules, 2003

COMPLETE SPECIFICATION

(Section 10 and Rule 13)

AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES

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The following specification particularly describes the invention and the manner in which it is to be performed.

FIELD OF INVENTION

Many efficient segmentation techniques found to have limitations in converting inhomogeneous to homogenous. In this work, efficient Markov Random Field (MRF) models are developed for segmenting the medical MR images and the performance evaluation of these has been carried out with known quality metrics and noise reduction factor.

BACKGROUND

Image segmentation plays a vital role in processing of medical images; this technique is widely used in remote sensing, biomedical image processing, satellite imaging, and quality testing. Segmentation helps to extract valuable data from the images to identify various objects present. Many efficient segmentation techniques found to have limitations in converting inhomogeneous to homogenous. The main aim of this segmentation is to detect valuable data to identify various important objects present in images. The problems of image segmentation have vanished through a collection of stages of improving the algorithm and alteration in the literature of segmentation. However, it is not possible for particular segmentation tool to meet consistent output required at all situations. There are mainly three fundamental approaches of segmentation: region based segmentation, boundary based approach and pixel classification approach. The segmentation method look for image attributes called features. The extracted image attributes used for enclosure of pixels depend on the similarity of features. Region segmentation technique based on the homogeneity of spatial domain intense contained attributes and statistical pixel properties. The thresholding is a simple region based segmentation technique. Threshold plays still a major role in the greater part of composite real images, which give unsatisfactory outputs. Frequently, this difficulty is considered a categorization of pixel problem and therefore treated as a pixel classification difficulty.

The pixels in the experimental image are converted into a label designating the region or category to its own. All the segmentation models are generally classified as supervised and unsupervised techniques. They have the following conditions (i) Labeling the pixels systematically (ii) The expansion of precautive values for the connected unknown model parameters, and (iii) Evaluation of labeling for each pixel of the image. The features can be easily recognized based on popular statistical methods by way of segmentation.

PRIOR ART DISCUSSION

US9129382B2 A technique for mind tumor division in multi-parametric 3D MR pictures. The strategy involves: pre-preparing an info multi-parametric 3D MR picture; characterizing each voxel in the pre-handled multi-parametric 3D MR picture, deciding the likelihood that the voxel is essential for a cerebrum tumor, and getting an underlying mark data for the picture division dependent on the characterization likelihood; building a diagram based portrayal for the pre-handled picture to be fragmented; and creating the sectioned mind tumor picture utilizing the underlying name data and chart based portrayal. This technique attempts to abuse the nearby and worldwide consistency of the picture to be fragmented for the tumor division and can mitigate incompletely the exhibition corruption brought about by the between subject picture fluctuation and inadequate measurable data from preparing.

Recognition and division of mind tumors in attractive reverberation pictures is critical in clinical conclusion. Dependable and exact tumor division gives supportive data to careful arranging and treatment getting to. The tumor division can likewise be utilized for general demonstrating of an obsessive cerebrum and the development of neurotic mind chart books. In any case, manual division of mind tumor pictures ordinarily utilized in centers is tedious, work escalated and emotional to impressive variety in intra-and between rater execution. Likewise, a strategy for completely programmed cerebrum tumor division is attractive. Tireless endeavors have been made to accomplish time-productive, precise, and reproducible tumor division. It anyway stays a moving assignment to accomplish powerful division as cerebrum tumors contrast much in appearance, area, size, and shape.

As of late, chart based picture division strategies have been utilized for clinical picture division, for example, diagram cut, arbitrary strolls, and such. The chart cut sections a picture utilizing locale and edge based data, wherein the area based data is accomplished by ascertaining the likelihood of every pixel having a place with the closer view/foundation, and the edge based data is estimated by the component comparability between pixels, including picture force likeness and spatial vicinity. Wels et al., "Strategy and System for Brain Tumor Segmentation in 3D Magnetic Resonance Images", U.S. patent Application Publication, Pub. No.: US 2010/0027865 uses the PBT (probabilistic boosting tree) classifier and diagram slice exhaustively to portion a mind tumor, wherein the PBT classifier accomplished from the preparation dataset is utilized to give the estimation of district based data and the picture power closeness is utilized as the edge based data. In any case, the regulated PBT classifier depends on the picture consistency between preparing pictures and the picture to be fragmented, and its presentation might be debased by picture commotion, MR picture predisposition field and between subject picture fluctuation. The area based data absolutely from the prepared measurable data isn't generally dependable, and the untrustworthiness will prompt incorrect diagram cut division results. Moreover, the edge based data estimated uniquely between neighboring voxels isn't hearty to the picture commotions, and may influence the presentation for the identification of a tumor limit.

US20180268942A1 Techniques and frameworks for deciding if cerebrum tissue is characteristic of a problem, for example, a neurodegenerative issue, are given. The strategies and frameworks for the most part use information preparing procedures to survey a degree of compatibility between estimated boundaries acquired from attractive reverberation imaging (MRI) information and recreated boundaries got from computational demonstrating of cerebrum tissues.

Neurodegenerative illnesses prompting dementia are an enormous cultural weight, presently decimating 9 million individuals locally and 47 million individuals around the world. Momentum failure to successfully forestall, analyze and battle neurodegeneration brings about stunning immediate and roundabout costs Alzheimer's infection (AD), the most well-known reason for dementia, alone distresses more than 5 million Americans and records for the sixth driving reason for death in the USA. Promotion requires an expected 18 billion hours of unpaid caretaking and well over $250 billion of clinical expenses every year. Pervasiveness of the sickness is extended to heighten to almost 14 million individuals locally and 135 million worldwide by 2050, with no expected fix in prompt sight. There is a critical requirement for mechanical headways toward diagnostics, avoidance, therapeutics and possible fixes that will each have significant gainful effects on the populace.

Momentum clinical assessment commonly incorporates non-intrusive mind imaging with attractive reverberation imaging (MRI), positron emanation tomography (PET), or other progressed imaging methodologies which give knowledge into tissue volume changes, synthetic creation, cortical metabolic rate, adjustments related with tissue cellularity and sickness biomarkers, and auxiliary variations from the norm credited to neurodegenerative infection. To help in the finding of AD and differential determination from non-Alzheimer dementias, fluorodeoxyglucose (FDG) PET and amyloid PET uncover AD-related examples of cerebral cortical digestion and beta amyloid stores in the dim issue, individually. Essentially, tau PET uncovers neurofibrillary tangles in the cerebrum. Nonetheless, because of an absence of progression in examination advancements, important utilization of these imaging procedures for neurodegenerative illness is limited to late stages when extensive tissue harm and intellectual or other clinical variations from the norm are available. As we develop our comprehension of the variety of variations from the norm related with AD, there is expanding proof that the nonstop focusing of these amyloid plaques and neurofibrillary tangles may just be treating late stage side effects instead of the fundamental causes. The powerlessness to viably distinguish beginning phases of AD blocks pre-indicative mediation and hides the possible helpful impacts of medication up-and-comers.

Understood to the neurodegenerative cycle is the demise of the flagging nerve cells in the cerebrum, however this can only be a definitive outcome in a course of degeneration inside mind tissue. The auxiliary uprightness of tissue is essential for neuron backing and endurance and leeway of atomic waste that must be eliminated from the mind for support of neural tissue homeostasis and proficient capacity. Adjustments in non-cell segments of the cerebrum are complicit in the degenerative cycle and might be a forerunner of lost nerve cell work. It has been demonstrated that legitimate guideline of neural tissue homeostasis is essential for taking out poisonous buildup development, a cycle that can be adjusted in the AD cerebrum. However, there stays restricted comprehension of cerebrum auxiliary substance and its effect on vehicle of particles in the mind interstitium. Right now, the clinical use and the analytic limit of cerebrum MRI stays restricted to differential conclusion, simply after indicative introduction, essentially because of the characteristically low spatial goal—MRI picture voxels are in mm measurements, though auxiliary changes adding to tissue degeneration begin at the sub-micron scale. FDG, amyloid, and tau PET sweeps experience the ill effects of comparative impediments.

US20120093381A1 A strategy for cerebrum tumor division in multi-parametric 3D MR pictures. The strategy involves: pre-preparing an information multi-parametric 3D MR picture; grouping each voxel in the pre-handled multi-parametric 3D MR picture, deciding the likelihood that the voxel is essential for a cerebrum tumor, and acquiring an underlying name data for the picture division dependent on the arrangement likelihood; building a chart based portrayal for the pre-handled picture to be sectioned; and creating the portioned mind tumor picture utilizing the underlying mark data and diagram based portrayal. This strategy attempts to abuse the neighborhood and worldwide consistency of the picture to be sectioned for the tumor division and can ease mostly the exhibition corruption brought about by the between subject picture fluctuation and deficient measurable data from preparing.

Recognition and division of mind tumors in attractive reverberation pictures is vital in clinical analysis. Solid and exact tumor division gives accommodating data to careful arranging and treatment getting to. The tumor division can likewise be utilized for general displaying of a neurotic cerebrum and the development of obsessive mind chart books. Notwithstanding, manual division of mind tumor pictures normally utilized in centers is tedious, work escalated and emotional to impressive variety in intra-and between rater execution. Likewise, a technique for completely programmed mind tumor division is attractive. Tireless endeavors have been made to accomplish time-proficient, exact, and reproducible tumor division. It anyway stays a provoking errand to accomplish powerful division as mind tumors vary much in appearance, area, size, and shape.

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The medical image segmentation for brain MR image needs a special implementing procedure to identify the ordinary subjects as well as subjects with tumor. The recognition of changes that occur in the brain can be studied by invasive and drastic improvement of technologies. The application of medical image processing includes shape analysis, study on neurons, brain related problems and therapy evaluations. X-Rays, MR images, and computed Tomography (CT) images are the medical images used to define the shape by using area and volume of region of interest. The medical experts have been facing difficulties in identifying the abnormalities in brain MR images. The emerging of various medical instruments made the process of diagnosing difficult with less error rate. Typical image features are likely to be understood in a wrong way and that leads to incorrect diagnosis. Therefore, it is very important to design a robust method to analyze great mass of information quickly and make diagnosis process easy and error free. In this direction, there is a great need to improve the segmentation algorithms for more accurate.

MR imaging is a healthy- recognized non – invasive technique based on the high intensity of magnetic field by occurrence. The quality of image investigation is frequently satisfactory for identifying disorders, but found to have more advantages. Thus, segmentation of MR images is a challenging task due to its complex structure of the brain that fully captures the essential deformations in every shape. These methods are evaluated based on weighted average of spectral and sequential data from the brain tissues to do analysis. The grayscale value of human tissue is uniform and has the construction of every tissue is inter connected, apart from that it is not easy to find the neighboring tissue and difference in their intensity values. The brain tissues are complex and study of complication gives exact partition of tissues of human brain image shapes. The visualization of brain structure is difficult without segmentation because the brain MR image has three major components which are called cerebrospinal fluid, white matter, and gray matter. Hence, medical image segmentation has become very significant component and attracted several researchers in the recent years.

Brain MR Image Segmentation

In the perception of medical imaging, brain Magnetic Resonance Image (MRI) segmentation is a composite task. The segmentation of brain tumor is an important point for diagnosing the tumors and also to understand the mechanism of mind and feelings. It is very hard to segment the brain MRI with tumor due to the following factors: 1.The tumor mass is twisted and tangled with healthy tissues is difficult to segment. 2. Edema (swelling) portion around the brain is mixed with white matter. 3. Gradually changing nature in edema boundary will create difficulty to distinguish the boundaries. 4. To identify the tumor by using the normal MR modality, T1 weighted image by means of disparity improvement ("naturally using gadolinium"), is not a regular practice. The blood cells and Cerebrospinal Fluid (CSF) are liable to be tinted next to tumor, whereas the tumor that necrotic tissue cannot be improved which is not possible by thresholding the T1 weighted image. For research and clinical applications, such as multimodality fusion and registration, learning of shapes, planning for surgery, useful mapping of brain region is used for classification of diseases, age segmentation, investigation on diseases, and tissues for image segmentation is very interesting and tricky. In the beginning, it is significant and essential to investigate MR images for better diagnosis using computer vision, because, the real time image acquisition in nature is based on inhomogenity, so medical image segmentation is a very difficult and tricky task.

In the medical diagnostic process, the segmented MR images are used and depend on a grouping of two, frequently difficult that should be take care about the subtraction of the redundant data in order to there in the inventive MR images along with the preservation of the important particulars within the consequential segmented images. Image segmentation of MR methods are typically based on their aptitude to distinguish i) different tissues present in brain ii) connecting usual tissues and tumor tissues. Several methods projected in the current existence, that are used for the segmentation of brain tissues from MR image, are classical pattern recognition methods, feed-forward neural networks, image analysis methods, connected component analysis, rule-based systems, crisp and fuzzy clustering procedures, fuzzy reasoning and determine the boundaries of the segmented objects, the methods like connected component analysis, deterministic annealing, atlas based methods and contouring approaches.

The segmentation methods are expected to provide information about shape, structures, and description for pathological studies. MRI techniques mainly benefit for imaging human brain. MRI applications are extensive and more useful for imaging human brain than any other parts of human body because of its visualization capability.

Problems and Challenges of Brain MR Image Segmentation

All the techniques are not fitting for medical image analysis because of complexity and inaccuracy. Produce satisfactory results for all imaging applications like brain MRI, brain cancer diagnosis etc., till now no standard image segmentation technique is found to be developed. The best possible selection of features, tissues, brain and non–brain elements are considered as main obstacles for brain image segmentation. Accurate segmentation over full field of view is another obstacle. Operator supervision and manual thresholding are other barriers to segment brain image. During the segmentation procedure verification of results is another area of difficulty.

OBJECT

- The goal of this innovation is to portion a cerebrum tumor in a multi-parametric 3D MR picture, consequently. To understand this, a programmed technique is given, settling:

- pre-handling an info multi-parametric 3D MR picture; and

- arranging each voxel in the pre-handled multi-parametric 3D MR picture, deciding the likelihood that the voxel is essential for a cerebrum tumor, and getting the underlying mark data for the picture division dependent on the characterization likelihood; and

- building a diagram based portrayal for the pre-handled picture; and

- creating the fragmented mind tumor picture utilizing the underlying mark data and chart based portrayal.

- This technique attempts to abuse the nearby and worldwide consistency of the picture to be portioned for the tumor division, hence, it can mostly ease the presentation corruption brought about by the between subject picture changeability and lacking measurable data from preparing.

Inventive step

The brain tissues segmented by using MRI and Computed tomography (CT) give better perspective on diagnosis of different brain disorders. Several segmentation techniques such as Histogram thresholding, region based segmentation, K-means, Expectation and Maximization (EM), Fuzzy connectivity, Markov Random Fields (MRF) are effectively applied for brain MRI. Hidden Markov Random Field (HMRF) technique is one of the best segmentation techniques which can solve efficiently different brain tissues for recognition. By applying HMRF model, it is possible for minimization of energy along with image smoothing. The main object of this study is to improve segmentation quality by using a novel Hidden Markov Random field model and applying MATLAB simulations to implement in Spatial Fuzzy, Iterative Conditional Mode (ICM) algorithm, Fuzzy MRF technique and Hidden Markov Random field model. The comparison of the results with Histogram thresholding, Region Growing method (RGM), k-means technique and Expectation and Maximization techniques will be accomplished to evaluate segmentation quality and noise reduction.

PERFORMANCE MEASURES

In this work, the performance of existing algorithms and proposed algorithms are compared with Signal to Noise Ratio (SNR) and Quality metrics. The quality of signal is calculated in terms of signal to noise ratio is defined as:

$$SNR_{dB} = 10\log_{10}\left(\frac{1}{N^2}\sum_i \frac{x_i^2}{\sigma^2}\right) \quad (1.1)$$

The segmentation performance is evaluated by using objective and subjective evaluation criteria based on Jaccard Coefficient (JC), Volumetric similarity (VS), Global Consistency Error (GCE), Variation of Index (VOI) and Probability Random Index (PRI) as follows:

Assuming X and Y to represent ground truth tumor and output tumor images:

$$\mathrm{JC} = \frac{|X \cap Y|}{|X \cup Y|} = \frac{a}{a+b+c} \quad (1.2)$$

$$\mathrm{VS} = 1 - \frac{||X| - |Y||}{|X| + |Y|} = 1 - \frac{b-c}{za+b+c} \quad (1.3)$$

Where $a = |X \cap Y|, b = \left|\frac{X}{Y}\right|, c = \left|\frac{Y}{X}\right|, d = |\overline{X \cup Y}|$

$$\mathrm{GCE}(S, S') = \frac{1}{N}\min\{\sum \mathrm{LRE}(S, S', x_i), \sum \mathrm{LRE}(S', S, x_i)\} \quad (1.4)$$

Where, $\mathrm{LRE} = \frac{|C(S,x_i) \setminus C(S',x_i)|}{|C(S,x_i)|}$

S and S' are segment classes and x_i is the pixel.

VOI(X,Y) =H(X) =H(Y) – 2I(X;Y) (1.5)

$$PRI(S_t, \{S\}) = \frac{1}{\binom{N}{2}} \sum_{i,j,i<j} [I(l_i^{St} = l_j^{St})p_j + I(l_i^{St} \neq l_j^{St})(1-p_j)] \quad (1.6)$$

Where, $p_j = P(l_i = l_j) = \frac{1}{k}\sum_{k=1}^{k} I(l_i^k = l_j^k)$and the values range from 0 to 1. 1 denotes the segments are identical.

NOVELTY

Motivation and Work Contributions

Human faces lot of problems with brain disorders and diagnose problems needs engineering perspective through medical image segmentation. In this work, statistical and stochastic models are adopted to find a better solution for real time difficulties faced in clinical diagnosis. To achieve the objectives, quite a few models have been developed for segmentation of image along with their key features and limitations.

In the last four decades, the popular statistical and stochastic models are used in image segmentation. From that Histogram threshold model, Region Growing method, K-means technique and Expectation and Maximization give better performance in medical image segmentation.

By using histogram based threshold, the image can be segmented into two non-overlapping sets that are objects and background, based on gray level value of histogram, select the threshold or critical value. Gray level pixels surpass original threshold value are allocated to single set and subsequently to the other. Such methods work well, though if images with especially uneven histogram approaches based on global measures didn’t.

In order to overcome the selection of this thresholding process, Region Growing Method (RGM) is more suitable. RGM is an easy region-based image segmentation technique, also called pixel-based image segmentation; it involves the collection of primary seed points. This method of segmentation observes adjacent pixels of initial “seed points” and finds whether the adjacent pixel should be added to the region or not. The main drawback of this method is selection of seed points manually and hence leads to inaccuracy of parameter estimation.

The k-means technique is a simple unsupervised iterative classification method, which doesn’t require prior information of data. In this technique, a mean intensity for each class is computed iteratively and segmenting the image by classifying each pixel in the class by the closest mean. The main disadvantage of the k-means algorithm is that an amount of cluster k is a key parameter. The assumption of k may project unfortunate results.

In recent years stochastic models appears to play a dominant role in image processing. Among them Expectation and Maximization (EM), Fuzzy C-means (FCM) and MRF (Markov random field) provide an improved structure for different typical problems in image segmentation. The steps involved in EM algorithm are: 1.An image is partitioned into number of classes. 2. Based on histogram of image to estimate the number of classes. 3. Execute the Expectation-step and Maximization-step iteratively until convergence. 4. The Expectation-step computes the class probability of each pixel based on the current estimation. 5. Based on values of Expectation-step, the new expectation is determined in Maximization-step. The maximum estimator is produced at the end of convergence. After that to generate the classification matrix and used for maximum likelihood in a classifier. Based on the classification matrix assigns color or label to each class then the segmented image is generated. Fuzzy C-means collects all pixels with similar characteristics into regions. The pixels belong to many regions with unreliable degree of membership which is difficult to estimate. The limitation of FCM is that spatial information is not considered.

To overcome that limitation we proposed Spatial Fuzzy C-Means (SFCM) technique. Integration of the spatial information into the membership functions by using SFCM. The spatial domain is enumerated to obtain clustering distribution information for the membership function of the neighborhood on a pixel. These values are distorted into a weighting function and incorporated into membership function. In this method the selection of parameters are difficult.

To provide an improved structure intended for various composite difficulties in image segmentation, another stochastic model MRF is proposed. MRF model used the basic idea of neighborhood structure that depends on global interactions from region to region local spatial relations. In this model, we proposed Iterative Conditional Mode algorithm, which combined label and boundary MRF. In addition to this, the global communication is governed by Gibbs distribution, subsequently identified the work of Geman & Geman and Besag. They applied MRF technique for image renovation, which can be viewed as overview of segmentation. Geiger and Ginose too added a second MRF (line process) to the work of Geman & Geman innovative MRF for surface record function. MRF based method has been widely used by researchers.

In this work, another popular stochastic Fuzzy MRF model is proposed. The Markovian distribution parameters are distinct in relationship with the function as of class, after that the original cost function based on the constraints of class only through CGM (conjugate gradient method) is applied.

But, complicated image features coupled with eye fatigue may sometime cause an expert to miss an abnormality in an image. Hence, there is a need to develop right algorithms that are capable to process huge data for diagnosis purposes with greater accuracy. In this work, efficient Markov Random Field (MRF) models are developed for segmenting the medical MR images and the performance evaluation of these has been carried out with known quality metrics and noise reduction factor. We proposed Spatial Fuzzy C-Means technique. This method is compared with existing methods and it is found to provide better results in terms of quality metrics even in presence of noise. The Spatial Fuzzy C-Means algorithm is found to be perceptive to the primary set of parameters and unsuitable for diagnosis as accuracy and boundaries of the areas of importance. To overcome these limitations, we have suggested Iterative Conditional Mode algorithm (ICM) in Markov Random Field (MRF) theory. This method has provided with better results in identifying affected areas. But, ICM algorithm requires moderately fine preliminary condition at the time of initialization with a constraint that a single label can be changed at a time. Hence, it is very much essential to have an algorithm that can be applied for labeling, identification of image boundaries and to find the location of tumor in MRI. A novel method of brain MR image segmentation called Fuzzy – MRF using Conjugate Gradient method is developed. It is found that the segmentation results obtained from Fuzzy – MRF are very accurate in terms of quality metrics and noise reduction. But, the estimation of parameter is found to be difficult; it requires prior simulations and not identified latent or hidden variables. Finally, Hidden Markov Random Field (HMRF) model developed, in this model, the systems believe a Markov process with latent or hidden states and the dependence of the output on the state is noticeable, even though the state is hidden. Based on output tokens probability distribution for each state can be calculated. HMM furnish information of succession of states by generated sequence of tokens. The state sequence is referred by hidden, but not the parameters of model. Even, if the model parameters are known exactly the state is still hidden.

For better diagnosis, a popular statistical Markov model i.e., Hidden Markov Random model (HMRF) is proposed. In this model, the system considers a Markov process with latent or unobserved states. Here, the output dependent on the state is noticeable, through the state is hidden. Based on output tokens we calculated probability distribution for each state. HMM furnish information of succession of states by generated sequence of tokens. The state sequence is referred by hidden, but not the parameters of model. Even, if the model parameters are known exactly the state is still hidden. The brain MR images used in this work are available at: http://www.bic. mni.mcgill.ca /brainweb.

The results obtained from Hidden Markov Random Field model are compared with Fuzzy-MRF model. Finally, it is observed that the segmentation results obtained from HMRF model are more accurate in terms of quality metrics more effective in dealing images in a noise environment.

CLAIM (S)

1. A method for brain tumor segmentation in multi-parametric 3D magnetic resonance (MR) images, comprising:
   pre-processing an input multi-parametric 3D MR image;
   classifying each voxel in the pre-processed multi-parametric 3D MR image, determining and assigning a classification probability that the voxel is part of a brain tumor

2. The method of claim 1, wherein the Histogram threshold technique and Region Growing Method (RGM) are applied on Brain MR Images to detect the tumor tissues even in noise and evaluate the quality metrics.
3. The method of claim 1, wherein the K-means and EM techniques are applied on Brain MR Images to detect the tumor and analyze the results for performance measures.
4. The method of claim 1, wherein the Spatial Fuzzy-C means technique is proposed is able to provide improved segmentation results than all the existing methods like Histogram, Region growing, K-Means and Expectation Maximization methods.
5. The method of claim 1, wherein the Iterative Conditional Mode (ICM) technique for MRF proposed on Brain MR Images is able to identify abnormalities of the brain MR images. In this model, combined the label and boundary of image and proved to be better segmentation results than SFCM's.
6. The method of claim 1, wherein the Conjugate gradient technique for Fuzzy MRF (FMRF) model is proposed, estimates implicitly mean and variance of the image and provides faster results than ICM with flexibility to vary more than one label at a time.
7. The method of claim 1, wherein the Hidden Markov Random field model proposed to detect the tumor tissues is able to provide better results because of including hidden states than FMRF.

ABSTRACT

AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES

Image segmentation with a focus on Magnetic Resonance (MR) images of brain has become very essential in diagnosis of abnormality in the brain. Identification of gray scale values of brain tissues is complex in nature because inhomogeniety. Identifying brain disorders deeply depend upon perfect segmentation of three brain tissues namely Cerebro-Spinal Fluid (CSF), White Matter (WM) and Gray Matter (GM) of MR image. The segmentation methods addressed in the literature could neither able to yield the labeling nor identify the boundaries of an image to locate the tumor and effected area. In this work, initially, the brain MR image segmentation has been performed by using statistical and stochastic models such as Histogram thresholding, Region Growing method, K-means method and Expectation Maximization (EM) algorithm to identify tumor with and without noise in brain MRI. These are simple threshold, distance based segmentation techniques and do not consider spatial information while processing, which is an important parameter in the image segmentation. Finally, Hidden Markov Random Field (HMRF) model developed, in this model, the systems believe a Markov process with latent or hidden states and the dependence of the output on the state is noticeable, even though the state is hidden. The results obtained from Hidden Markov Random Field model are compared with Fuzzy- MRF model. Finally, it is observed that the segmentation results obtained from HMRF model are more accurate in terms of quality metrics more effective in dealing images in a noise environment.

FORM 3
THE PATENTS ACT 1970
(39 of 1970)
&
The Patent Rules, 2003
STATEMENT AND UNDERTAKING UNDER SECTION 8
(See Section 8, rule 12)

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Hereby declare, We have not made any application for the same / substantially the same invention outside India.

TITLE OF THE INVENTION: AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES

Name of the signatory	Signature	Date
Dr. A. Ramaswami Reddy		01/12/2020

To
The Controller of patents, The Patent office at CHENNAI

FORM 5
THE PATENTS ACT, 1970 (39 of 1970)
&
THE PATENTS RULES, 2003
DECLARATION AS TO INVENTORSHIP
(See section 8, rule 12)

1. Name of applicant **Dr. A. Ramaswami Reddy**

Hereby declare that the true and first inventor of the invention disclosed in the complete specification filed in pursuance of my application numbered _____________ dated ___________________
TITLE OF THE INVENTION**: AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES**

2. Inventors

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Dr. Sk Jakeer Hussain	Associate Professor, Department of Computer Science and Engineering, Malla Reddy Engineering College (Autonomous), Dhulapally (Post), Maisammaguda, Gundlapochampally (V), Medchal (M), Medchal - Malkajgiri District, Secunderabad – 500100. Telangana State	Indian
Dr. Raghunath Pasunuri	Associate Professor, Department of Computer Science and Engineering, Malla Reddy Engineering College (Autonomous), Dhulapally (Post), Maisammaguda, Gundlapochampally (V), Medchal (M), Medchal - Malkajgiri District, Secunderabad – 500100. Telangana State	Indian
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Mr. S. Ajay Kumar	Associate Professor, Department of Computer Science and Engineering, Malla Reddy Engineering College (Autonomous), Dhulapally (Post), Maisammaguda, Gundlapochampally (V), Medchal (M), Medchal - Malkajgiri District, Secunderabad – 500100. Telangana State	Indian

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3.Declaration to be given when the application in India is filed by the Applicant in the convention country: -
I the applicant in the convention country hereby declare that our right to apply for a patent in India is by way or assignment from the true and first inventor.

Name of the signatory	Signature	Date
Dr. A. Ramaswami Reddy		01/12/2020

To
The Controller of patents
The Patent office at CHENNAI

FORM 9

THE PATENTS ACT, 1970
(39 of 1970)
&
THE PATENTS RULES, 2003
REQUEST FOR PUBLICATION
(See section 11A(2); rule 24A)

We (state name, address and nationality of applicant & inventors)

Name	Address	Nationality
Dr. A. Ramaswami Reddy	Director, Malla Reddy Engineering College (Autonomous), & Professor, Department of Computer Science and Engineering, Malla Reddy Engineering College (Autonomous), Dhulapally (Post), Maisammaguda, Gundlapochampally (V), Medchal (M), Medchal - Malkajgiri District, Secunderabad – 500100. Telangana State	Indian
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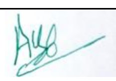
Hereby request for early Publication of our application for Patent No. ____________________ dated _______________ under section 11A(2) of the act.

TITLE OF THE INVENTION: AN EFFICIENT MRF MODELS FOR DETECTION OF BRAIN ABNORMALITY BASED ON MR IMAGES

Name of the signatory	Signature	Date
Dr. A. Ramaswami Reddy		01/12/2020

To

The Controller of patents, The Patent office at CHENNAI