Abstract: The segmentation in medical images especially in the field of MR image is a challenging task in the presence of intensity inhomogeneity. So many techniques have been devised to correct this artifact. The intensity inhomogeneity also known as intensity non uniformity refers to the slow, non atomic intensity variations of the same tissue over the image domain. This paper attempts to review some of the recent developments in the modeling of intensity inhomogeneity field. This IIH mainly occurs due to the imperfections in imaging devices, lightning and illumination effects. The imperfections in the image acquisition process, manifests itself as a smooth intensity variation across the image. Due to the presence of intensity non uniformity the segmentation results are not accurate. So this survey paper describes various techniques for image segmentation in the presence of intensity inhomogeneity. Intensity inhomogeneity are considered to be multiplicative low frequency variations of intensities that are caused by the anomalies of the magnetic field of scanners. Intensity non uniformity is caused by the overlaps between the ranges of intensities in the region to be segmented. This survey paper covers segmentation techniques to overcome the intensity inhomogeneity and obtain accurate results.

Keywords: Image Acquisition, Image Domain, Intensity Inhomogeneity, Medical Images, MR Image, Segmentation.
1. Introduction:

The technique and process used to create the images of human body is medical imaging. With the help of imaging technology such as MRI, CT, Ultrasound in medicine the doctors can see the interior portions of the body for easy diagnosis. It also helped doctors to make keyhole surgeries for reaching the interior parts without opening too much of the body. The main applications of medical imaging are used for clinical purposes. CT scanner, Ultrasound, MRI, X-ray are some of the imaging techniques. The method of partitioning a digital image into multiple segments is image segmentation. The image segmentation is not accurate in the presence of intensity inhomogeneity. Intensity Inhomogeneity occurs in real world images because of various factors such as spatial variations in illumination and imperfections of imaging devices, which cause many problems in image processing and computer vision. Image segmentation is very difficult for images with intensity inhomogeneity. This intensity inhomogeneity mainly occurs due to the overlaps between the ranges of the intensities in the region to segment. The region based segmentation algorithm works well for homogeneous objects. Existing level set methods [1] for image segmentation can be categorized into two major classes, region based models and edge based models. This survey paper mainly covers the method for correcting intensity inhomogeneity with an application to Magnetic resonance images.

The intensity measured for magnetic resonance images are seldom uniform; rather it varies smoothly across an image. The IIH is usually attributed to poor radio frequency, gradient-driven eddy currents, and patient movement both inside and outside the field of view. The MR images are mainly considered because of its advantages over other medical imaging modalities. The presence of IIH can reduce the accuracy of image segmentation and registration. In the simplest form, the model assumes that IIH is multiplicative or additive. This can state as the IIH field multiplies or adds the image intensities. For modeling inhomogeneity that are due to induced currents and non uniform excitation, the multiplicative model is less appropriate [2]. The most popular model in describing the Intensity Inhomogeneity effect is

\[ y = ay' + \xi, \]

Where \( y \) denote the measured intensity and \( y' \) the true intensity. The \( a \) denotes the IIH effect and \( \xi \) denotes the noise. The assumptions about this can be stated as, IIH field or the bias field is slowly varying which implies that it can be approximated to a constant and the true image
takes constant values in disjoint regions. The popular mathematical models for IIH can be described as Low frequency models, hyper surface models, statistical models and others.

Low frequency models which assumes the low frequency components in the frequency domain and the bias field can be recovered by low pass filter

Hyper surface model fits the IIH by a smooth functional and the parameters are obtained using regression.

Statistical model assumes the IIH to be a random variable or a random process and the bias field can be derived through statistical estimation.

Others which are based on various principle this paper is organized as follows. Section 2 gives idea about Magnetic Resonance Images. Section 3 describes about Image Segmentation in the field of medical image processing. Section 4 describes the classification of Intensity Inhomogenity Correction methods. Section 5 gives a summary regarding various segmentation methods applied to medical images in the presence of Intensity Inhomogenity. Section 6 describes the conclusion.

2. Magnetic Resonance Image:

An important application of image segmentation is in the field of medical image processing. Imaging technology in medicine made the doctors to see the interior portions of the body for easy diagnosis. It also helps doctors to make keyhole surgeries for reaching the interior parts without really opening too much of the body. Medical imaging constitutes a sub-discipline of biomedical engineering, medical physics or medicine depending on the context. Many of the techniques developed for medical imaging also have scientific and industrial applications. Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems. This means that cause is inferred from effect. The term non-invasive is a term based on the fact that following medical imaging modalities do not penetrate the skin physically. But on the electromagnetic and radiation level, they are quite invasive. From the high energy photons in X-Ray Computed Tomography, to the 2+ Tesla coils of an MRI device, these modalities alter the physical and chemical environment of the body in order to obtain data. There are so many imaging techniques are available. Magnetic Resonance Imaging took over x-ray imaging by making
the doctors to look at the body's elusive third dimension. Quantitative means of analyzing Multidimensional image data is MRI. MRI traditionally creates a two dimensional image of a thin "slice" of the body and is therefore considered a tomography imaging technique. Modern MRI instruments are capable of producing images in the form of 3D blocks, which may be considered a generalization of the single-slice, tomography concept. Unlike CT, MRI does not involve the use of ionizing radiation and is therefore not associated with the health hazards. MRI provides high quality images of the inside parts of the human body. The advantage of using MRI is that no ionizing radiation is involved. In this paper mainly we are focusing the Intensity inhomogeneity correction in MR images.

3. Image Segmentation:

Image segmentation, as mentioned above is widely used in content based image retrieval, Machine vision, Medical Imaging ,Object detection, Pedestrian detection, Face detection, Brake light detection, Locate objects in satellite images, Recognition Tasks, Iris recognition, Traffic control systems. The main applications of medical imaging are Locate tumors and other pathologies, Measure tissue volumes, Diagnosis & study of anatomical structure. Medical imaging which consists mainly combination of sensors recording the anatomical body structure like magnetic resonance image (MRI), ultrasound or CT with sensors monitoring functional and metabolic body activities like positron emission tomography (PET), single photon emission computed tomography (SPECT) or magnetic resonance spectroscopy (MRS). Results can be applied, for instance, in radiotherapy and nuclear medicine. This paper mainly deals with the application on magnetic resonance image. . Image segmentation is a process in which regions or features sharing similar characteristics are identified and grouped together. Image segmentation may use statistical classification, thresholding, edge detection, region detection, or any combination of these techniques. The output of the segmentation step is usually a set of classified element. Most segmentation methods are region based and edge based. Region-based techniques rely on common patterns in intensity values within a cluster of neighboring pixels. The cluster is referred to as the region, and the goal of the segmentation algorithm is to group regions according to their anatomical or functional roles. Edge-based techniques rely on discontinuities in image values between distinct regions, and the goal of the segmentation algorithm is to accurately demarcate the boundary separating these regions. Segmentation is a process of extracting and representing information from an image is to group pixels together into regions of similarity.
The categories of image segmentation mainly include Clustering Methods - Level Set Methods, Histogram-Based Methods- Graph Partitioning Methods, Edge Detection Methods- Watershed Transformation, Region Growing Methods- Neural Networks Segmentation. The image segmentation is a very difficult task if Intensity Inhomogeneity is present in the image. The segmentation results are not accurate due to the presence of IIH.

4. Classification Of Iih Correction Methods:

Various IIH correction methods have been proposed. In the following section we propose a classification scheme based on the image acquisition process. Two main approaches have been applied to minimize the IIH in MR images. They are prospective method and retrospective methods. Prospective method usually correct the IIH at the time of image acquisition process where as retrospective method correct IIH on the information of the acquired image and the knowledge about the image. The prospective methods are classified into Phantom, Multi coil and Special sequences. The retrospective methods are classified into filtering, surface fitting, segmentation and histogram based. The filtering methods are Homomorphic and Homomorphic unsharp masking. The surface fitting methods are intensity and gradient method. The Segmentation methods include Maximum Likelihood (ML) or Maximum a posteriori probability (MAP) criterion which is used to estimate the intensity distribution of the image based on parametric model. The other methods in segmentation include Fuzzy c-mean and nonparametric model. The Histogram correction method includes High frequency maximization, information minimization and Histogram matching. Prospective methods treat IIH corruption as a systematic error when we acquire an image with the help of MRI. This can be minimized by acquiring additional images with different coils are by using special imaging sequences. IN the retrospective methods only a few assumptions about the data acquisition process are usually made. These methods mainly lie on the information of the acquired images by the useful anatomical information and information on the IIH are combined. The prospective method are mainly used to correct IIH induced at the time for acquiring an image with the help of MR scanner where as retrospective method can remove the patient dependent inhomogenity.
5. Literature Survey:

5.1 Image Segmentation Based On Inhomogenity Pixel Using Complex Wavelet Transform For Medical Images [3]:

This paper proposes a novel region wavelet based method for Image segmentation which can deal with Intensity Inhomogenity. During Segmentation the Intensity Inhomogenity is identified by the efficient threshold technique in wavelet domain. The proposed method is used to identify intensities with wavelet domain. Wavelets, the essential signal in transform domain gives a superior performance. There are Discrete Wavelet Transform (DWT) and Discrete Wavelet Packet Transform (DWPT) which are shift varying. The Dual Tree Complex Wavelet Transform (DTCWT) is approximately shifting invariant and provides directional analysis. The proposed method combines two thresholding techniques namely Neighshrink and Sureshrink to identify the inhomogenity. The techniques likes Visushrink is thresholding by applying the universal threshold. Neighshrink proposed for each inhomogeneity wavelet coefficient to be shirked, incorporating a square neighborhood window. Sureshrink is a thresholding technique in which adaptive threshold is applied to sub band, a separate threshold is computed in detail for each sub band based on SURE. Neighsureshrink is an unbiased estimate of the risk on sub band in the neighborhood window size. The advantages are better identification of contours and IIH. Neighsureshrink the new threshold method with complex Wavelet transform and Achieves better results in terms of SSIM and CWSSIM. The Wavelet Transform suffers due to poor directionality and does not provide a geometrically oriented decomposition in multiple domains.

5.2 An Efficient Local Chan–Vese Model For Image Segmentation [4]:

This paper mainly presents a new local CV model for image segmentation based on the technique of curve evolution, local statistical function and level set method. The proposed model energy functional consists of local term, global and regularization term. The local image information is combined with the CV model, segmentation can be achieved. The traditional level set method, time consuming re initialization is used which is avoided in this model by adding a new penalizing energy. An efficient termination condition is presented based on extended structure tensor(EST) to avoid the long iteration process for level set evolution. EST is obtained by adding the intensity information into the classical structure tensor for image segmentation. By combining the EST with our LCV model the segmentation
can be achieved, if the texture image contains IIH or not. Level set method is the active contour model for segmentation of deformable structure. The Mumford Shah model, original image is approximated by a smooth function. A termination criterion (based on length of the evolving curve) for curve evolution is also described in this model. The proposed model also implements texture image segmentation which consists of two steps, first a texture representation is selected and texture features are extracted from initial image. Second the objective function can be defined using texture features. The advantages are the model describes the efficiency and robustness on synthetic and real images and less sensitive to the location of the initial contour. Disadvantages are LCV model is proposed for two phase model, multiple objects in different intensities is difficult.

5.3 Parametric Estimate Of Intensity In Homogeneities Applied To MRI [5]:

This paper presents a new correction method called parametric bias field correction mainly describes a simplified model of the imaging process. A parametric model of tissue class statistics and a polynomial model of the inhomogeneity field. The image is corrupted in the presence of noise and a low frequency inhomogeneity field. The parametric bias field is estimated as a nonlinear energy minimization problem using an evolution strategy (ES). Mainly used to correct bias distortions much larger than the image contrast. The polynomial approach bias correction with histogram adjustment is combined to make suitable for normalizing the intensity histograms of datasets. The model is based on the observation that a pixel value of the corrupted image still belongs to a single class, but its value is moved away from the class mean. The PABIC method is driven by the assumption that the idealized scene can be modeled by pixel composition which belongs to a small number of classes with known statistics. In MR images PABIC has been applied routinely for various clinical purposes. Non linear optimization is the method to estimate the parameter of a 2D/3D inhomogeneity field. PABIC can be described as a optimization of polynomial parameter with respect to a cost function based on image classification likelihood. Advantage is the method combines bias correction with histogram adjustment, makes it well suited for normalizing the intensity histogram. The disadvantage is the computation time decreases linearly when sub sampling is used.
5.4 Inhomogeneity Correction For Magnetic Resonance Images With Fuzzy C-Mean Algorithm [6]:

This paper presents the effect of image IIH is a challenging problem and must be considered in any segmentation method. The adaptive fuzzy C mean algorithm already exists, which can provide very good result in the presents of inhomogeneity effect under the low noise level condition. Their results deteriorate quickly as a noise level gross up. This paper proposes a new fuzzy segmentation algorithm to improve the performance of the AFCM algorithm. The fuzzy c mean algorithm the accurate segmentation results are obtained in the presence of IIH effect and high noise levels by in cooperating the spatial neighborhood information in to the objective function the standard fuzzy c mean algorithm expressed as the minimization of the objective function with respect to the membership function and centroid of each class. The standard FCM algorithm does not work for images with IIH and noise. So the AFCM algorithm was proposed. Depending on the MRF based segmentation methods performs well under very noisy situations. The AFCM algorithm is modified to incorporate the immediate neighborhood for an improved noise performance. This paper mainly proposed a new IIH correction method for MR images based on AFCM and incorporates new constraint terms in to the objective functions. Advantage is new method is more robust even in the conditions of high noise. Disadvantage is the minimization process is a kind of conjugate gradient method and cannot process the global minimum.

5.5 A Multiphase Level Set Framework For Image Segmentation Using The Mumford And Shah Model [7]

This paper proposes a new multiphase level set frame work for image segmentation using the Mumford and Shah Model for piece wise constant and piece wise smooth optimal approximations. This method is a generalization of active contour model without edges based two phase segmentation. In the case of piece wise smooth only two level set functions formerly suffix to represent any partition based on the four colour theorem, in the piece wise constant case only log n level set functions for any phases in the piece wise constant case. This avoids the problem of vaccum and overlaps and represents boundaries with complex topology including triple junction. We can validate the proposed models by numerical results for signal and image de noising and segmentation implemented using the Osher and Sethian level set method. The active contour model without edges was partition of a given image into two regions, one region representing the object to be detected and the other representing the
back ground. The AC was given by the boundary between these two regions. The problem we
generalize was active contour (binary segmentation) to segment images with more than two
regions. The solution we use is the multiphase level set frame work. The model can be
described with piece wise constant and piece wise smooth approximations. This paper we
introduced a new multiphase model for MS image segmentation by level set. The multiphase
formulation is different than the classical approaches. The advantage is that the phases cannot
produce vacuum or overlap by construction and it minimizes the computational cost by
reducing the number of level set functions. Disadvantages is that only two level set functions
are implemented, difficult to for multi level set functions.

5.6 A Variational Level Set Approach To Segmentation And Bias Correction Of
Images With Intensity Inhomogenity [8]:

This paper presents a variational level set approach to join segmentation and bias corrections
of images with intensity inhomogenity. Intensities in small local regions are separable despite
of the inseparability of the intensities in the whole image caused by intensity inhomogenity.
A weighted k mean clustering objective function is defined for image intensities in a
neighborhood around each point, with the clusters centers having a multiplicative factor that
estimate the bias with in the neighborhood. The objective function is then integrated over the
entire domain and in cooperated in to a variational level set formulation. The energy
minimization is performed by a level set evolution process. This method is able to estimate
bias of general profiles. Bias correction methods can be of prospective and retrospective
methods. The former method states that the intensity correction at the time of acquisition
process. The latter method removes intensity inhomogenity regardless of their sources such
as filtering, surface fitting and histogram. The method should follow two conditions. The bias
field is slowly varying in the entire image domain. The time image intensities are
approximately a constant within each class of tissue. Energy is formulated. Minimize this
energy with the help of level set evolution process. K-mean clustering property is used to
cluster the image which is a weighted function .The level set formulation mainly consists of
N=2(two phase) and N=4(multi phase process) By this we can reduce energy formulation and
hence the segmentation is done. The advantage of this method is not sensitive to initialization
and thereby allowing automatic applications.Reinitialization is also possible in this method.
Disadvantage is method is able to estimate bias of general profiles.
5.7 A Variational Multi Phase Level Set Approach To Simultaneous Segmentation And Bias Correction [9]:

This paper mainly represents a novel level set approach to simultaneous tissue segmentation and bias correction of MRI. The sliding window is used to transform intensity from one dimension to another. The objective function is distributed over each point and integrated over the entire domain to form a variational level set evolution. With the help of level set evolution process tissue segmentation and bias correction are achieved. The bias signal is the constant true signal and is spatially varying field. To unify segmentation parametric model based on maximum likelihood or maximum a posterior probability is used, whose parameters depend on Expectation maximization algorithm. These algorithms are sensitive to the initialization of variables which limits their application in automatic segmentation. The proposed method uses a variational level set approach to simultaneous segmentation and bias correction. The method uses a k-Means clustering which is weighted k-means variational level set. The proposed method use a special case SVMLS-Statistical & variational multiphase level set. We incorporate the energy functional into a multiphase level set formulation. Intensity can be approximated by Gaussian distribution with mean and variance. Minimizing the energy functional we get the corresponding gradient descent. Tissue segmentation is more accurate than WKMLS. Advantage of this method is that the smoothness of the computed bias field is ensured by the normalized convolution without extra cost. The evolution is less sensitive to the initialization that well suited for automatic applications. Disadvantage is to define a maximum likelihood objective function for each point in a transformed domain.

5.8 Variational Image Segmentation Models: Application To Medical Images MRI:

An important branch of computer vision is image segmentation. By extracting one or several objects or by dividing images in contiguous semantic regions is the main aim. Since the natural images are diverse, complex and the way we perceive them vary according to individuals. So segmentation is very difficult to achieve. The image segmentation problem can be solved with the help of mathematical frame work based on variational model and partial differential equations. The framework is defined in a continuous setting which makes the proposed model independent with respect to the grid of digital images. Segmentation is very useful in vision systems and medical applications. The main aim is to semantically describe the important parts of the image. The various approaches for segmentation are global
approaches, contour approaches, region approaches, continuous approaches and Markov models. This paper mainly introduces a segmentation method based on Variational approach. This model is defined in a continuous setting and is mathematically well established.

Two well known image segmentation models based on variational approach is specified. They are Mumford Shah model and level set approach. The Mumford Shah model is mainly used to minimize the energy function. In traditional level set methods it is necessary to initialize the level set method function as a signed distance function. This method suggests the following function as the initial function. Hence the method is more suitable. Advantages are the proposed model is defined in a continuous setting which makes the model independent with respect to the grid of digital images. Disadvantage is the problem is highly dependent on initial conditions and the convergence is not always fast.

6. Conclusion:

The survey paper mainly presents a framework for segmentation and bias correction of medical images in the presence of intensity inhomogenity. Image Segmentation is a very difficult task in the presence of intensity inhomogenity. The Segmentation algorithms typically rely on the homogeneity of pixel values. The presence of non uniformity of pixel values leads to inhomogenity. The Segmentation results are not accurate due to the presence of the above artifact. From all the above papers we can formulate that with the use of certain methods intensity inhomogenity can be resolved from medical images and make them suitable for applications. The methods are well suited for Magnetic Resonance Images. The proposed methods suggests that in the presence of intensity inhomogenity also, segmentation can be successfully performed with better results.
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