Soft White Tissue Detection From Pressure Ulcer Images Using Anisotropic Diffused Total Variation Fuzzy C Means

Raja.S
Assistant Professor
Sri Shakthi Institute of Engineering and Technology
Coimbatore 641062, Tamilnadu, India
e-mail: raja.s@siet.ac.in

Ranjith Kumar.R
Assistant Professor
Sri Shakthi Institute of Engineering and Technology
Coimbatore 641062, Tamilnadu, India
e-mail: rranjithece@siet.ac.in

Abstract— The goal of image segmentation is to cluster pixels into salient image regions. It can identify the regions of interest in an image or annotate the data. In medical imaging, these segments often correspond to different tissue classes, pathologies, or other biologically relevant structures. Medical image segmentation is made difficult by low contrast, noise, and other imaging ambiguities. The goal of segmentation of pressure ulcer images is to find out the level of tissue wound and soft white tissue present. Soft white tissue protein level changes are mostly found in elderly people. Soft white tissue present may be dark red or light yellow gel based on the different imaging modes of severity of pressure ulcer. This helps in diagnosing the disease and to plan for the treatment. The soft white tissue detection is made difficult for the segmentation because of the noise present in the image. Clustering techniques are best suited to segment the input images with noise. Clustering is usually performed when no information is available concerning to the membership of data items to predefined classes. For this reason clustering is traditionally seen as a part of unsupervised learning.

Keywords*- Feature extraction, detection and segmentation, CAD system, statistical approach.*

*****

I. INTRODUCTION

Fuzzy clustering techniques are best suited to segment the pressure ulcer images because the uncertainty of pressure ulcer image is widely presented in data. The most and powerful segmentation is the Fuzzy C Means (FCM) clustering algorithm because, more information is preserved. The focus is this work is to improve the FCM approach and applies it to pressure ulcer image segmentation for detecting Soft white tissue present in pressure ulcer image. The method used to improve FCM are Total Variation (TV) Regularization where noise from the image is eliminated but results in stair casing effect, which is further improved by Anisotropic Diffusion (AD) is to eliminate the stair casing effect (Zhu et al 2008).

II. OVERVIEW OF THE SYSTEM

The goal of segmenting a medical image is to simplify the representation of an image into a meaningful image and makes it easier to analyze. As a first step, pressure ulcer image is pre-processed using Pixel Normalization technique which is one of the efficient image enhancement techniques. The pre-processed image is subjected to segmentation (Zhuang Miao et al 2011). The segmentation includes Fuzzy C Means Clustering (FCM) which is improved by Total Variation Fuzzy C Means (TVFCM) (Chambolle et al 2011) by modifying the objective function

of the FCM. Total Variation Fuzzy c-means method is solved using Alternative Direction Methods of Multipliers (TVFCM with ADMM). The method takes longer time to reconstruct the images, therefore Anisotropic Diffusion (AD) (Jing Huo et al 2009) method is used along with the Total Variation Fuzzy c-means (ADTVFCM) to eliminate the disadvantage of the TVFCM, Anisotropic Diffused Total Variation Fuzzy c-means is then solved using Majorize Minimize Algorithm (ADTVFCM with MM).

III. ARCHITECTURAL DESIGN

The input image for the system is taken as pressure ulcer affected image of human for detecting Soft white tissue present. First, pressure ulcer affected area (leg, heel) of the human is pre-processed using Image Pixel Normalization. Pixel Normalization is the image enhancement technique that is commonly used for medical images. In the second step, the pre-processed image is subjected to segmentation. Pressure ulcer image is segmented by Fuzzy C Means Clustering (FCM) (Yanyan He et al 2012) and the method is improved by Total Variation Fuzzy c-means (TVFCM) and solved using the Alternative Direction Method of Multipliers. The method takes longer reconstruction time; hence Anisotropic Diffused (AD) is used along with TVFCM to reduce the steps in the reconstruction of the image. The ADTVFCM is solved using Majorize - Minimize method.

Fuzzy C Means (FCM) is an unsupervised method derived from fuzzy logic that is suitable for solving multiclass and ambiguous segmentation problems. Although FCM is a very useful method for performing segmentation, its memberships do not always correspond well to the degrees of belonging of the data, and it may be inaccurate in a noisy environment. To improve this weakness of FCM, a regularizing parameter is added in addition with the objective function to minimize the noise. The approach reduces the noise but results in blurred edges. To overcome this disadvantage, Anisotropic Diffusion is performed by reinterpreting the TVFCM, which removes stair casing effect and the noise from the image, to show that ADTVFCM method is more robust and also it preserves the edges.

A major disadvantage of FCM method is that it is sensitive to noise and incomplete data and hence the objective function of FCM method is modified using the TV method and is minimized using the ADMM to obtain the optimized result. The method takes more time in reconstruction of the image. Therefore AD is used along with TVFCM in reducing the time as well as it eliminates the noise, the method is then minimized using MM to get the optimized result.

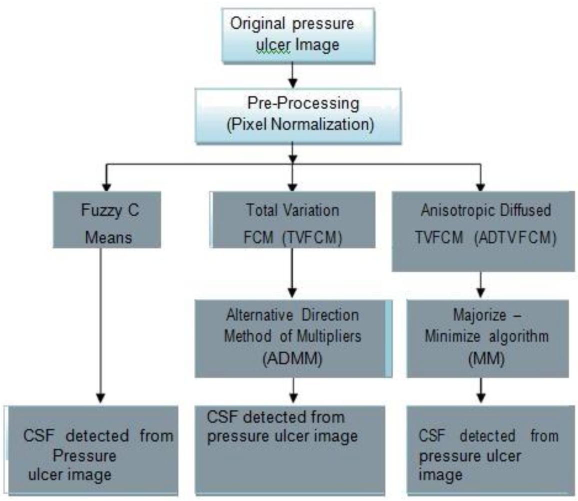

Figure 1 Overall Process of the System

IV. FUZZY C MEANS ALGORITHM

Fuzzy C Means (FCM) has been a very important tool for image processing in clustering objects in an image (Krishnamoorthy et al 1998, Esser et al 2010). Fuzzy c-means (FCM) clustering is an unsupervised technique that has been successfully applied to feature analysis, clustering, and classifier designs in the fields such as astronomy, geology, medical imaging, target recognition, and image segmentation (Udupa et al 1997).FCM clustering is an unsupervised technique that is used for feature analysis, clustering, in fields such as medical imaging, target recognition, and image segmentation. There are many acceleration techniques for FCM; there are very large data versions of FCM that utilize both progressive sampling and distributed clustering; there are many techniques that use FCM clustering to build fuzzy rule bases for fuzzy systems design; and there are numerous applications of FCM in virtually every major application area of clustering. Fuzzy c-means (FCM) clustering is an unsupervised technique that has been successfully applied to feature analysis, clustering, and classifier designs in the fields such as astronomy, geology, medical imaging, target recognition, and image segmentation (Udupa et al 1997). There are various features spaces in which an image can be represented, and the FCM algorithm categorizes the image by assembling similar data points into clusters. This clustering is achieved by iteratively minimizing a cost function that is dependent on the distance of the pixels to the cluster centers in the feature domain.

The cluster center and the new membership function are calculated iteratively. The iteration continues until the user specified value or the iteration continues until difference between last two iterations has minimum value. It was proved (LászlóSzilágyi et al 2007) that there exists a subsequence of U and V which converges to a local minimizer or a saddle point of J if f contains at least C different gray values.

Figure 2: Pressure ulcer affected patient Image on various stages with different visit

Steps in FCM

1. The Pre-processed pressure ulcer is taken as the input
2. Cluster center has been randomly selected
3. The new membership function $(uk(j)^{m})$ is calculated
4. Fuzzy center (vk) has been computed
5. Step 3 and 4 are repeated until the minimum objective value is achieved.

V. EXPERIMENTAL SETUP

Anisotropic Diffused Total Variation Fuzzy C Means (ADTVFCM) Algorithm

Total Variation Regularization for image segmentation results in stair casing effect and takes longer reconstruction time. The diffusion process can be done on the image to remove the disadvantage of TV. The Anisotropic Diffusion algorithm is the pioneering work in partial derivatives equations (PDE)-based denoising. AD is a technique aiming at reducing image noise without removing significant parts of the image content, typically edges, lines or other details that are important for the interpretation of the image. It applies the law of diffusion on pixel intensities to smooth textures in an image.

ISSN: 2454-4248
23 – 26

A threshold function is used to prevent diffusion to happen across edges, and therefore it preserves edges in the image. The anisotropic diffusion filter as a diffusion process that encourages intra region smoothing while inhibiting inter region smoothing.

Anisotropic diffusion resembles the process that creates a scale space, where an image generates a parameterized family of successively more and more blurred images based on a diffusion process. Each of the resulting images in this family is given as a convolution between the image and a Gaussian filter, where the width of the filter increases with the parameter. This diffusion process is a linear and space-invariant transformation of the original image. Anisotropic diffusion is a generalization of this diffusion process: it produces a family of parameterized images, but each resulting image is a combination between the original image and a filter that depends on the local content of the original image. As a consequence, anisotropic diffusion is a non-linear and space-variant transformation of the original image.

- Input Image - Pre-Processed pressure ulcer image
- Output image - CSF Detection Using ADTVFCM.

Steps in ADTVFCM

1. The pre-processed pressure ulcer image is taken as input.
2. Pixel value is selected.
3. The diffusion is performed by diffusion equation.
4. The diffused values are filtered using convolution filter.
5. The objective function of traditional TVFCM is applied to the filtered image.

VI. EXPERIMENTAL RESULTS

Pressure ulcer images are useful for detecting soft white tissue present in the image. A number of different imaging modes can be used with imaging the brain: T1: soft white tissue is dark in red with long wound area. T1 weighting is useful for visualizing normal anatomy. T2: soft white tissue is light, but fat (and thus white matter) is darker than with T1. T2 is useful for visualizing pathology. FLAIR: useful for evaluation of white matter plaques near the ventricles. It is useful in identifying demyelization. T2 weighted images are better suited for detecting soft white tissue present in the pressure ulcer brain images.

Dataset: The proposed system is tested on a database of 150 pressure ulcer images with different noise levels. The database is shown in the Figure 4.3.The pressure ulcer images are collected from the database http://brainweb.bic.mni.mcgill.ca/brainweb/ selection_ms.html.

Input pressure ulcer Image: The Original pressure ulcer Image is taken from the dataset for segmentation. The input image considered is either colored image or gray image.

Pre-processing (Pixel Normalization): In order to increase robustness, the noisy medical image is pre-processed using Bright Pixel Normalization.

Fuzzy C Means (FCM): When FCM is applied, numerous small regions around the lobes (ventral, parietal, occipital and temporal) (Riemenschneider et al 2002) are incorrectly detected.

Total Variation Fuzzy c-means (TVFCM) with Alternative Direction Methods of Multipliers (ADMM): TV eliminates the noise in the image by introducing the regularizing parameter. The value chosen is adjusted in order to get the output by eliminating the noise but results in blurred image (Chambolle et al 2011). ADMM is used to minimize the optimization problem of TVFCM. The objective function of the TVFCM is minimized.

The performance of the proposed method for detecting soft white tissue level in pressure ulcer Brain image is calculated using segmentation accuracy (SA). The formula for SA is given as shown in the equation. The input Brain image is corrupted by white Gaussian noise with different noise levels. The FCM, TVFCM and ADTVFCM method are compared and it is found that ADTVFCM outperforms the other methods.

The segmentation accuracy is given as in the following equation Segmentation Accuracy = No.of correctly classified pixels / No. of pixels

The segmentation results of FCM and TVFCM with different noise levels for the pressure ulcer image in the database is shown in the Table 1. It is shown that segmentation accuracy by ADTVFCM method yields 98.8% when compared to the segmentation accuracy of FCM, TVFCM. The results of ADTVFCM have segments with smoother boundaries and the edges are preserved.

Table 1 Performance Analysis for Segmentation Accuracy

Methods Noise Level (%)	FCM SA (%)	TVFCM SA (%)
3	97.5	98
5	95.7	97
7	88.2	95.8

ISSN: 2454-4248
23 – 26

The performance analysis for Table 1 is shown in the Figure. 3, the different noise levels are plotted in horizontal coordinates and the segmentation accuracy is plotted in the vertical coordinates.

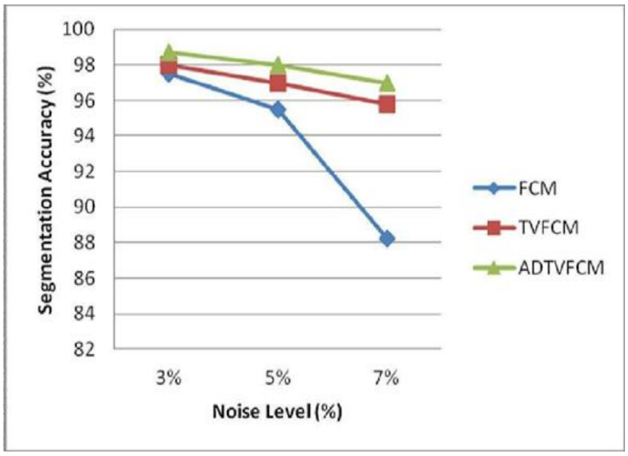

Figure 3 segmentation accuracy comparisons with different noise level.

VII. EXPERIMENTAL RESULTS

Anisotropic Diffused Total Variation Fuzzy C Means segmentation method based on new objective function is well adapted and efficient for functional pressure ulcer data to detect the soft white tissue present. The detection of soft white tissue present is used to identify the disease in pressure ulcer images such as Alzheimer disease. The proposed segmentation method is more robust than the TVFCM and FCM algorithm. ADTCFCM method eliminates the noise in the image and it works properly on gradient-sparse images. The proposed method minimizes the stair casing effect and ringing artifacts that are common with traditional TV. The Majorize Minimize algorithm is used for the minimization of ADTVFCM method to obtain the results with good segmentation accuracy. The sensitivity and specificity for FCM and TVFCM provides more false positives than ADTVFCM. Experimental results over pressure ulcer image datasets show that ADTVFCM is efficient and can reveal very encouraging results in terms of quality of solution found.

REFERENCES

[1] S.Guo, Y. Kato, H.Itoand T. Mukai, "Development of rubber-based flexible sensor sheet for care-related apparatus",SEI Technical Review, Vol. 75, Pp. 125-131, 2012.
[2] J. Vivanco, J. Haydaman, C. Hamel, R.D. McLeod and M.R. Friesen, "Development of wound care software for smart phones and tablets", Vol. 3, No. 3, Pp. 13-14, 2016.
[3] J.A. Cafazzo, M. Casselman, N. Hamming, D.K. Katzman and M. R. Palmert, "Design of a mHealth app for the self-management of adolescent type 1 diabetes: A pilot study",Journal of medical Internet research,Vol. 14, No. 3, Pp. 70-75, 2012.
[4] L. Wang, P.C. Pedersen, D.M. Strong, B. Tulu, E. Agu and R. Ignotz, "Smartphone-based wound assessment system for patients with diabetes",IEEE Transactions on Biomedical Engineering, Vol. 62, No. 2, Pp. 477-488, 2015.
[5] M.R. Friesen, C. Hamel, and R.D. McLeod, "A mHealth application for chronic wound care: Findings of a user trial",International journal of environmental research and public health, Vol. 10, No. 11, Pp. 6199-6214, 2013.
[6] P.J.White, B.W.Podaima and M.R. Friesen, "Algorithms for smartphone and tablet image analysis for healthcare applications",IEEE Access, Vol. 2, Pp. 831-840, 2014.
[7] C. Kratzkeand C. Cox, "Smartphone technology and apps: rapidly changing health promotion",Global Journal of Health Education and Promotion, Vol. 15, No. 1, 2012.
[8] D.L. Berry, B.A. Blumenstein, B. Halpenny, S. Wolpin, J.R. Fann, M. Austin-Seymour and R. McCorkle, "Enhancing patient-provider communication with the electronic self-report assessment for cancer: a randomized trial", Journal of clinical oncology, Vol. 29, No. 8, Pp. 1029-1035, 2011.
[9] A. Samad, S. Hayes, L.Frenchand S. Dodds, (. Digital imaging versus conventional contact tracing for the objective measurement of venous leg ulcers. Journal of wound care, 11(4), 137-140. 2002)
[10] S. M. Rajbhandari et al (2014) 'Digital imaging: An accurate and easy method of measuring foot ulcers' Diabetic Med., vol. 16, no. 4, pp. 339-342.