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A Review on Techniques used on X-Ray Image Stitching

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***Abstract*—Multiple single x-ray images are combined and a single large, high resolution image of the whole hand structure or full body parts can be produced in Medical image stitching whereas conventional screen film provides limited field of view in standard X-ray images which does not give a view of full long bone structure of large hands or full body part in a single frame. The traditional method for x-ray image is single, noisy & with less accuracy. New technologies developed, x-ray radiography, Computer Tomography, Magnetic Resonance imaging to overcome these limitations are widely used to detect fracture in long bone, to detect cancer, chest problem and many more. In this paper, technologies used for image stitching to improve image quality, automatic interpretation of fracture injury site, to detect brain tumor is covered.**

***Index Terms*— Medical image, image stitching, x-ray radiography, Computer Tomography, Magnetic Resonance imaging.**

I. INTRODUCTION

This Medical imaging greatly contributed in disease diagnosis, monitoring and treatment. Now a days Medical imaging has become a practice in Medical field. Medical imaging is a technique, in which interior of a body can be visualized for clinical analysis, image guided surgery, Therapy planning, treatment and follow up replacing conventional techniques. In this paper, number of technologies, approaches is discussed related to medical image stitching [1].

In computer vision multiple single images are aligned and stitched seamless to create a large image called photo mosaic or panorama. Applications of Medical imaging are detection of bone fracture in a long bone structure, Tumor detection, Lungs cancer, diabetic Radiography etc. Technologies used in Medical imaging are x-ray Radiography, X-ray Computer Tomography (CT) Ultra-sound (US), MRI (Magnetic Resonance Imaging), Endoscopy, single photon emission tomography (SPET), Medical Photography, Positron Emission Tomography (PET) etc. In advance Medical X-ray imaging stitching 2D X-ray is replaced by 3D x-ray technique.

Image stitching or Mosaicing extends the field of view. The panoramic effect with a very high resolution is widely used in Medical system and hence become very popular to diagnose the disease, monitoring the state of health or analysis of these images. Magnetic Resonance Imaging today is widely used in advanced medical imaging technique. MRI provides clear picture of normal as well as abnormal tissues with good contrast resolution more than CT (Computer Tomography) for the brain tissues. So Researcher preferred MRI technique than CT technique.

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II. IMAGE STITCHING

Image stitching is carried out basically by three steps Calibration, Registration and Blending [1] as shown in Figure.1 calibration minimizes the difference between camera lens and ideal lens model [1] to reconstruct a panoramic image. In image registration multiple images are aligned which has been taken from different perspectives [3].

Figure.1 Basic steps of Image Stitching

Seamless image is created by applying image blending across the stitch. Two popular techniques used for image blending [5] are alpha feathering blending and Gaussian pyramid. When alignment of image pixels is well and there is only intensity difference between two images then alpha feathering blending technique is used. Images at different frequency bands are merged in Gaussian pyramid approach [3].

Image Stitching is classified in to two methods as Direct Based Registration method and Feature Based Registration method. In Direct method, pixel intensities of two images are compared using any available cost function. As it compares every pixel in the each window of two different frames, it requires high computational cost. Direct method provides optimal information, but gives limited range of convergence.

Initialization is not required in Feature based method. It compares the feature between two images using [5] one of the feature detector techniques. For most of the cases it becomes difficult to find feature in the component image [6]. This method is time consuming. Various Feature Based Techniques used in image stitching are, SIFT (Scale Invariant Feature Transform), Harris, SURF (Speed Up Robust Features), FAST (Features from Accelerated Segment Test), ORB, PCA-SFT techniques.

We are requesting that you follow these guidelines as closely as possible.

A. Medical Image Stitching

In Medical field, x-ray images are used to diagnose fracture in the bones, joint dislocation. It is also very useful in bone injuries or arthritis or in orthopaedic surgery. Conventional X-ray equipment consists of flat panel which has limited field of view. Large image with conventional x-ray equipment is created with special cassettes and multiple standard size films. To detect fracture in the long bone or abnormality in the any portion of the body part, standard x-ray image is not enough. In such cases large image is required which will cover whole body part.

In Medical Stitching, a large image can be created using multiple of standard x-ray images. This large image extends field of view and can be used easily for detection of fracture in the long bone or abnormality in the any portion of the human body parts. Large image is possible with Image Registration and Image Blending. In this multiple x-ray images are used with overlapping areas and stitch seamlessly to generate a large panoramic image with high resolution.

Standard x-ray images have limitation to show a long hand structure or full body parts. This limitation is overcome with Medical x-ray Image Stitching. From last so many years different approaches, techniques, algorithms are contributed in Medical Image Stitching. Salbiah et al. a new method is proposed with Minimum Average Correlation Energy (MACE) filter to identify merge overlapping and non-overlapping x-ray images of a hand bone structure and requires less computation time in [8].

Medical stitching is efficiently utilized in the diagnosis of the bone structure. Many times manual interpretation of the bone fracture tends to misdiagnosis. An automatic interpretation of a bone fracture injury is provided in x-ray image in [9]. Zheng et. al. new algorithm utilizes vertically Integral Projection for the proposed bone region and later projection curves combines.

Figure.2. Overlapped images (http://byrl.me/y46Oju [8]

Figure.3. Panoramic image (http://byrl.me/y46Oju) [8]

In Medical stitching image quality is an important factor for correct diagnosis. Noise level or low visibility in x-ray image outperforms the image quality. Paola et al. a new approach is proposed to denoise a x-ray image using a patch based filter [10]. Medical x-ray image stitching is regularly used in orthopaedic surgery, panoramic x-ray image stitching free from parallax of a long bone with good visual quality image during orthopaedic surgery with effective use of mobile c-arm[16].A conventional x-ray machine gives limited field of view become very difficult during long bone surgery. So axial alignment of a long bone is not viewed and needs one mare surgery for repositioning. Lejing Wanga et al. introduces a panoramic view of a x-ray image of a long bone free from parallax with considerable visual quality during orthopaedic surgery with the effective implementation of mobile C-arm.[16].

Telemedicine is popularly used to provide clinical health care from a long distance by expert doctors. Automation in the analysis of a x-ray image of a long bone fracture or osteoporosis is highly needed and can be helpful for the paramedical staff at remote places. Detection and analysis of a long bone fracture is proposed in a digital x-ray image technique[17], also a software tool is developed to detect bone region from the surrounding region in the body which can be easily used by doctors or paramedical staff to provide clinical health care, proper diagnosis at remote places.

Many times seamless image stitching of x-ray images becomes difficult because of low brightness and does not produce accurate result. Abhinav kumar et al. proposes a fully automatic stitching algorithm of x-ray images with varying degrees of overlap in a high resolution single image, it neither extract Features nor alignment process requires segmentation. It utilizes the intensity base technique, so it can be used for the images at different intensities, but is not rotational, scale and also translational invariant [18].

Effectiveness of surgery, treatment planning & computer aided diagnosis can be increased for 3D bone reconstruction using x-ray image segmentation. D.C.T.Nguyen et al. presented a multi- atlas fusion framework for the automatic segmentation in [20] of the complex bone structures with single x-ray image. A fracture in the lower leg bone (tibia bone) fracture from x-ray images is detected in this paper using classification method without segmentation step. Edge detection is done in pre-processing. Ilker Hacihalioglu et al. proposed a new approach for a fully automatic bone surfaces. In this paper, 3-D Log-Gabor filters are used that reduces processing time and improves classification accuracy [21]. In this article, automatic bone surface extracted from 3 D ultra sound images by using 3D log Gabor filters.

Digital Radiography (DR) has limitation to capture a full bone structure of x ray image in a single shot. Fan Yang et al., introduced a new image stitching method for lower limb and full spine x ray images [22]. To determine the best match, an improved phase correlation algorithm is used. To overcome the problem of inaccuracy in the overlapping region, multitime phase correlation is used. Proposed system is invariant to translation and rotation. Here overlapping area used is less than 30% and reduces average stitching time with down sampling. But in the cases with substantial exposure difference, this method fails in detecting overlapping region, for this problem to overcome author suggest, before phase correlation window function or histogram matching can be used.

Recently, Magnetic Resonance Imaging (MRI) become a most effective way to visualize brain structure and other body part, is widely used in advanced medical image technique. It provides good resolution for different brain tissues. It is extensively studied due to its sensitiveness towards human body [23]. Because of

the good resolution in MR image over the other imaging techniques used for diagnosis [23], the researchers now prefer to use MR images in image segmentation than CT images.

B. FCM Clustering and related extensions

In Fuzzy C-means(FCM) algorithm a method of clustering is developed by Dunn and improved by Bezdek in which one piece of data to belong to more than one clusters generally used in pattern Recognition. For partitioning an image in to the cluster c, the standard FCM objective function is,

The FCM algorithm continues an iteration until a solution is reached. To visualize brain structures (MRI Magnetic Resonance Imaging) become one of the most common way for diagnosis. It is computer aided system to study the main cerebral tissues, Gray & White matter for patient's diagnosis and follow up. During brain MR Images and clinical analysis segmentation is often required as an initial and necessary stage in the computer aided medical image process.

Wang et al[23] proposed a modified algorithm with fuzzy c-means (FCM) for MRI brain image segmentation. This proposed a method in which noise is reduced during a brain image segmentation of MR image. Using both local and non-local information, Distance measurement is modified for the FCM algorithm and pixel labeling is performed to reduce the noise, but this algorithm is computationally expensive makes its applicability limited specially for large volume data.

For quantitative and exact analysis of MR brain images, accurate segmentation of these images is a crucial requirement in todays medical field. Segmentation technique incorporated for 3D MRI, the Fuzzy C-Means (FCM) algorithm is a flexible approach and is widely used for automated image segmentation. Caldairou et al.[24] proposed an algorithm in which Fuzzy C Means and non-local framework is integrated. Non-local framework is used to handle the Intensity inhomogeneity and noise that generally observed in the MR images.

Gupta et al[25] introduced a new approach for medical image registration. Fuzzy *c*-Means (FCM) is used to obtain reference for image segmentation and floating-segmented images. The quality of image registration is determined by the volume control points of these segmented images. In this paper, Speeded Up Robust Feature (SURF) is used to extract the features from reference based on these volume control points and floating images, to accomplish image registration. Author says that the proposed registration algorithm is faster and robust against other image transformations quantitatively. For simulations, same image size but different scales are used. In this paper, results obtained are for different rotation angle translations in horizontally & vertically. Proposed method is for single modality and works good when the image is rotated at some angle.

Nabanita Mahataa et al [26] introduced, a fuzzy clustering algorithm is introduced by integrating Gaussian function and local contextual information, and is utilized to estimate intensity inhomogeneity for brain MR image segmentation. Chandan Singh et al.[27] Proposed a transform based MRI segmentation method, consists of both local and non-local information in the segmentation process. Transform domain guarantees noise insensitiveness and preservation of image.

Content Based Image Retrieval (CBIR) minimizes the problem of searching for similar images in a large image data base. Srinivas et al. [28] proposed a clustering method new dictionary learning based clustering method for content based image retrieval. To generate dictionaries for each cluster, Variance and Mean of the pixel intensity values with the K-SVD method are utilized.

Lung diseases now a prime factor for the death and disability worldwide. Radiologists recognized the lung diseases using CT images, face sometimes difficulty to identify the disease specially for the junior radiologists. Ling Ma et al.[29] Proposed a new method for content based medical image retrieval is proposed. Based on Visual and semantic similarities, a fused pair wise similarity can be achieved. Proposed method is applied to search for similar common CT imaging signs of lung diseases.

C. Challenges

Many times in a x-ray image a background region outperforms the actual information, so there is need to develop a powerful technique to select the required portion and remove the other part. There are limitations in MRI technique as RF noise, Intensity homogeneities, partial volume, Gibbs Ringing, Susceptibility. Also MR acquisition images takes more time than CT and difficult to obtain uniform image quality. High resolution image is the demand for today's Medical field for guided surgery, fractures in the long bones or abnormalities in the human body, research is needed to develop more algorithms to generate very high resolution images. For rotating images with different intensities a seam is generated on the overlapped portion. To create a seamless image in such cases for correct diagnosis, monitoring there is need to work on Blending technique. Apart from this for specific clinical applications new technologies for image analysis is

TABLE I. METHODOLOGIES UTILIZED IN LITERATURE SURVEY

Sr.No.	Title/ Year/Source	Author	Methodologies utilized	Observation
01	Automatic Panoramic Image Stitching Using Invariant Features", International Journal of Computer Vision, August 2007, 74 issue 1, pp59-73.	Brown, M., & Lowe, D. G.	Invariant local features technique SIFT to extract features, RANSAC is used to find best matches.	This method is insensitive to the ordering, orientation, scale, and illumination of the input images.
02	Robust image stitching with multiple registrations", Computer Vision –ECCV 2018,Springer international publication	Charles Herrmann , Chen Wang , Richard Strong Bowen, Emil Keyder , Michael Krainin ,Ce Liu ,and Ramin Zabih,	Proposed a new algorithm.	Proposed the use of multiple registrations, permitting regions of the image at different depths to be captured with greater accuracy and generate significantly better panoramas when there is substantial motion or parallax.
03	Research on Adaptive fusion algorithm for image stitching", Publication year 2017,pages:270-274, International Symposium on Intelligent Signal Processing and Communication Systems, November 6-9, 2017, Xiamen, China	T Zhimin Wei, Shengkui Dai, Caiming Lin,	Adaptive Multi-direction Image Fusion Algorithm	Estimate the type of image stitching rapidly and accurately and perform the corresponding multi-direction image fusion and eventually eliminate the seam-line.
04	A flexible patch based approach for combined denoising and contrast enhancement of digital X-ray images", ELSEVIER ,Medical Image Analysis 28(2016) 33-45.	Paolo Irreraa,b, Isabelle Blocha, Maurice Delplanqueb,	Proposed a new approach to denoise a x-ray image using patch based filter.	Noise level or low visibility of fine anatomical structures in x-ray image outperforms the image quality & is very important for correct diagnosis.
05	Stitching contaminated images",2016 ELSEVIER, Neurocomputing, 214(2016)829-836	Chuan Li, Zhi-Yong Liu, Xu, Yang, Hong Qiao, Jian-Hua su	Proposed a new algorithm.	Proposed a stitching method for denoising and partially contaminated input images contain moving objects.
06	Efficient Image Stitching of Continuous Image Sequence With Image and Seam Selections", IEEE Sensors Journal (Volume: 15 , issue: 10, Page(s): 5910 – 5918 , Oct. 2015)	Cheng-Ming Huang, Shu-Wei Lin, and Jyun-Hong Chen	Proposed a new algorithm.	The dominent frames which have dissimilar content with previously stitched result are utilized for stitching. The non dominant frames are used to localize the camera view on the mosaicked image.
07	Parallax-tolerant Image Stitching ", 2014,IEEE conference on Computer Vision and Pattern 8Recognition,ISBN:978-1-4799-5118-5 .	Fan Zhang and Feng Liu	Proposed a novel algorithm to handle parallax & avoid objectionable distortion.SIFT to detect features.	Developed a method that aligns input images locally to provide optimal stitching and content preserving warping is used to handle parallax.
08	Development of Automated Image Stitching System for Radiographic Images" , Society for Imaging Informatics in Medicine 2012, J Digit Imaging (2013) 26:361–370 .	Salbiah Samsudin, Somava Adwan, H.Arof	Proposed a Minimum Average Correlation Energy (MACE) filter	Minimum Average Correlation Energy (MACE) filter to identify merge overlapping and non-overlapping x-ray images of a hand bone structure and requires less computation time.
09	Parallax-free intra-operative X-ray image stitching ", ELSEVIER ,Medical Image Analysis 14 (2010) 674–686.	Lejing Wanga,, Joerg Trauba, Simon Weidert , Sandro Michael Heining, Ekkehard Euler , Nassir Navab	Presented a novel method	Parallax-free panoramic X-ray images during surgery by enabling the mobile C-arm to rotate around its X-ray source center, relative to the patient's table.

to be developed, also research to develop to analyses heterogeneous image data. Image segmentation is often a very important stage in clinical analysis of specifically brain MR images. New algorithms to be develop to generate clear and accurate picture of soft tissues of brain MRI.

III. CONCLUSIONS

This survey paper reviewed different approaches, methods, algorithms, techniques employed in Medical image stitching by different researchers. The study of reviewed work is presented in the summarized form. A unified technique for detection & evaluation for a long bone fracture in digital x-ray is discussed which can be conveniently used by paramedics or expert doctors. This paper basically focus on x-rays and MRI images related to bone structure, brain such as image stitching of a full bone structure, fracture injury site, detection of Tumor, parallax free intra x-ray image operative Stitching. MRIs are extensively used in clinical studies. A Fuzzy C Means algorithm for brain MRI segmentation is incorporated local and non-local contextual information is reviewed. Image corruption in MRI due to intensity inhomogeneity can be able to deal with non-local contextual information framework. The main drawback of FCM algorithm is that it is sensitive to noise. Robustness of the FCM algorithm is to be improved to solve this problem. Due to noise present in the MR images, an accurate image segmentation for the brain images is a tough and crucial task while analyzing analysis of these images. The main drawback of FCM algorithm is that it is sensitive to noise. Robustness of the FCM algorithm is to be improved to solve this problem. New or modified algorithms are to be proposed to overcome the limitations of MRI such as RF noise, Intensity inhomogeneity, Partial volume, Gibbs Ringing, Wrap Around, Motion, Gradients, and Susceptibility. The literature review of medical image stitching shows that there is a high need for improving the stitching process to extend the field of view with high resolution for guided surgery, detection of brain tumor, lung cancer in a human body. For detection, Analysis and monitoring of a human body part a parallax free, noise free panoramic, high resolution seamless image is to be generated.

REFERENCES

[1] Chia- Yen Chen, "Image Stitching- Comparisons and New Techniques", CTTR-TR-30, October 1998.

[2] Plumin JPW. Antiine Maintz JB, and Viergever MA," Mutual-information- based registration of medical images: a survey ", IEEE Trans Med Imaging.2003-22-986-1004

[3] Goodben A., Pralow T, Grigat RR, "Automatic stitching of digital radiographies using image interpretation", Medical Image Understanding and Analysis 2008.. Proceedings of the Twelfth Annual Conference, University of Dundee, 2008,pp204-208

[4] Brown LG, "A survey of image registration techniques", ACM Computing Surveys. 1992;24:325–376. doi: 10.1145/146370-146374.

[5] Szelisk R," R," Image Alignment and Stitching, "A Tutorial. Handbook of Mathematical Models in Computer Vision", New York: Springer, 2005, pp 273–292.

[6] Li Y, Ma L, " A fast and robust image stitching algorithm", Proceedings of the 6th World Congress on Intelligent Control and Automation, 21-23 June 2006, Dalian, China.

[7] Yu W, Mingquan W, " Research on stitching technique of medical infrared images", 2010 International Conference on Computer Application and System Modeling (ICCASM2010).

[8] Salbiah Samsudin, Somaya Adwan, H.Arof , "Development of Automated Image Stitching System for Radiographic Images", Society for Imaging Informatics in Medicine 2012, J Digit Imaging (2013) 26:361-370.

[9] ZHENG wei, ZHANG liming, "Study On Recognition Of The Fracture Injure Site Based On X-ray Images", 2010 3rd International Congress on Image and Signal Processing (CISP2010).

[10] Paolo Irreraa Isabelle Blocha Maurice Delplanqueb, "A flexible patch based approach for combined denoising and contrast enhancement of digital X-ray images Medical Image", Medical Image Analysis 28 (2016) 33-45.

[11] Greet Litjens Thijs Kooi , Babak Ehteshami Bejnordi , Arnaud Arindra Adiyoso Setio , Francesco Ciompi, Mohsen Ghafoorian, JeroenA.W.M. van der Laak, Bram van Ginneken Clara I., " A survey on deep learning in medical image analysis", Medical Image Analysis 42 (2017) 60-88.

[12] C.Spampinato , S. Palazzo , D. Giordano , M. Aldinucci , R. Leonardi, "Deep learning for automated skeletal bone age assessment in X-ray images", Medical Image Analysis 36 (2017) 41-51.

[13] Bezdek JamesYu W, Mingquan W, " Research on stitching technique of medical infrared images", 2010 International Conference on Computer Application and System Modeling (ICCASM2010).

[14] Vijaya Kumar BVK, Savvides M, Venkataramani K, Xie C., "Spatial frequency domain image processing for biometric recognition", IEEE ICIP, 2002,pp 53-56.

[15] Hua Ma, Ayla Hoogendoorn , Evelyn Regar ,Wiro J. Niessen , Theo van Walsum, "Automatic online layer separation for vessel enhancement in X-ray angiograms for percutaneous coronary interventions", Medical Image Analysis 39 (2017) 145–161, ELSEVIER.

[16] Lejing Wanga, Joerg Trauba, Simon Weidertb, Sandro Michael Heiningb, Ekkehard Eulerb, Nassir Navab, "Parallax-free intra-operative X-ray image stitching" , Medical Image Analysis 14 (2010) 674-686.

[17] Oishila Bandyopadhyaya, Arindam Biswasa, Bhargab B. Bhattacharyab, " Long-bone fracture detection in digital X-ray images based on digital-geometric techniques", _ Computer methods and Programs 123(2016)2-24, ELSEVIER.

[18] Abhinav Kumar, Raja Sekhar Bandaru, B Madhusudan Rao, Saket Kulkarni, Nilesh Ghatpande, " Automatic Image Alignment and Stitching of Medical Images with Seam Blending",International Science Index 41, 2010 waset.org/publications/12878, World Academy of Science, Engineering and Technology Vol:41 2010-05-21, View Record in Scopus, Google Scholar.
[19] Mahmoud, H., Masulli, F. and Rovetta, S. "Feature-based medical image registration using a fuzzy clustering segmentation approach", Proceedings of the 9th International Meeting on Computational Intelligence Methods for Bioinformatics and Biostatistics, 12–14 July, 2013,Houston, TX, LNCS, Vol. 7845, pp.37–47.
[20] D.C.T. Nguyen, S. Benameur , M. Mignotte , F. Lavoie, "Superpixel and multi-atlas based fusion entropic model for the segmentation of X-ray images", Medical Image Analysis 48 (2018) 58–74.
[21] Ilker Hacihaliloglu, Rafeef Abugharbieh, Antony J. Hodgson,Y, Robert N. Rohling,Y And Pierre Guyz,"Automatic Bone Localization And Fracture Detection From Volumetric Ultrasound Images Using 3-D Local Phase Features", Ultrasound in Med. & Biol., Vol. 38, No. 1, pp. 128–144, 2012.
[22] FanYang a, YanHe a,n, ZhenShengDeng b, AngYan, "Improvement of automated image stitching system for DRX-rayimages" , Comput Biol Med. 2016 Apr 1;71:108-14. doi: 10.1016/j.
[23] Wang Jianzhong, Jun Kong , Yinghua Lub, Miao Qi , Baoxue Zhang, "A modified FCM algorithm for MRI brain image segmentation using both local and non-local spatial constraints", Computerized Medical Imaging and Graphics 32 (2008), 685–698.
[24] Benoˆıt Caldairou,NicolasPassat , PiotrA.Habas , ColinStudholme , Franc-ois Rousseau,"A non-local fuzzy segmentation method: Application of brain MRI", Pattern Recognition 44 (2011) 1916–1927.
[25] Sunanda Gupta, S.K. Chakarvarti, Zaheeruddin, "Medical image registration based on fuzzy *c*-means clustering segmentation approach using SURF**",** Int. J. Biomedical Engineering and Technology, Vol. 20, No1,201633.
[26] Nabanita Mahataa, Sayan Kahalia, Sudip Kumar Adhikarib, Jamuna Kanta Sing, "Local contextual information and Gaussian function induced fuzzy clustering algorithm for brain MR image segmentation and intensity inhomogeneity estimation", Applied Soft Computing 68 (2018) 586–596 .
[27] Chandan Singh, Anu Bala, "A DCT-based local and non-local fuzzy C-means algorithm for segmentation of brain magnetic resonance images", Applied Soft Computing 68 (2018) 447–457.
[28] M. Srinivas, R.RamuNaidu , C.S.Sastry , C.KrishnaMohan, "Content biased medical image retrieval using dictionary learning", Neurocomputing168(2015)880–895.
[29] Ling Ma, Xiabi Liu , Yan Gao , Yanfeng Zhao , Xinming Zhao , Chunwu Zhou, "A new method of content based medical image retrieval and its applications to CT imaging sign retrieval", Journal of Biomedical Informatics 66 (2017) 148–158.
[30] Ivana DespotoviT, Bart Goossens, and Wilfried Philips, Review Article ,"MRI Segmentation of the Human Brain: Challenges, Methods, and Applications", Hindawi Publishing Corporation Computational and Mathematical Methods in Medicine Volume 2015, Article ID 450341, 23.