The Problems, Applications and Growing Interest in Automatic Segmentation of Medical Images from the Year 2000 till 2011

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***Abstract*—The researches have shown that incorrect analysis of images is often the result of improper segmentation. Because some troubles like the need to exact definition of Region of Interest (ROI), complex visual characteristics of diseases and difficulty of basic knowledge provision complicate the segmentation step in medical image analysis. Furthermore the segmentation methods are subject to the dimensionality and the modality of imaging. These are owing to a high dependency on factors such as disease type and ROI features. Consequently these reasons lead to remain the segmentation a challengeable and an interesting research field as well. Thus the number of literatures increases annually shown schematically in this paper. In this paper, some problems and applications of segmentation in medical imaging are summarized first and then the progress carrier is shown and proved with some charts in the eleven recent years by searching "image", "segment" and "medical" phrases on PUBMED, IEEE and Elsevier libraries.**

***Index Terms*—Medical image analysis, segmentation, artificial intelligence, number of literatures, problem, application.**

I. Introduction

The volume of medical data increases daily. It makes essential use of semi or automatic devices facilitated with modern IT tools to storage, collect, classify, retrieve and analyze medical data [1], [2].

Correct diagnosis and treatment of diseases is vital. It complicates medical imaging issues [1]-[4]. Artificial Intelligence (AI) algorithms have been shown promising results to automate medical devices and improve efficiency and reliability in medical data analysis [1]-[7]. Digital image processing and its combination by other AI methods like machine learning, fuzzy logic and pattern recognition are so advantageous in visualization and automatic analysis of medical images [6],[7]. Because accurate identification of biological features of ROIs has an important role in their analysis and various methods of AI help to simplicity and accuracy of this identification [8].

Segmentation is crucial as a first step in Medical Image Analysis (MIA) [1]-[10]. Because of the error resulting from the segmentation is transferred to later steps in MIA. It causes incorrect analysis of image ultimately. Therefore a correct segmentation method is critical. The Segmentation methods depend on modality and dimension of imaging. It is because of a high dependency on factors like disease type and image features. So these dependencies lead to the growth of the number of available literatures in this field [2]. To gain more information about MIA and especially medical image segmentation (MIS), there are some review articles such as [2], [4], and [6] - [20].

The rest of this paper is organized as follows. First it explains the segmentation phase of the MIA system in section II. Then some problems and applications of the MIS are mentioned in section III and IV respectively. Moreover, the progress carrier is shown and proved with some charts in the eleven recent years by searching "*medical*" and "*image*" and "*segment*" phrases together on PUBMED, IEEE and Elsevier digital libraries in section V. Finally the paper concludes in section VI.

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II. Segmentation in Medical Image Analysis

Todays, the growth of technology in medical imaging devices is significant. So MIA is regarded highly to be automatic. In other hand, automatic MIA is required due to its applications including in better understanding the type and location of disease and detection of the disease progression as well. Moreover, computed diagnosis, computed surgery, medical studying and research in the field of anatomy are of MIA results [7].

Reliable quantitative analysis of medical images namely volumes measurement needs to describe the anatomy of structures and segments of image. This operation is very difficult and is often done by a human operator. Unfortunately this manual segmentation is too time-consuming. So segmentation of many scans is not possible and affordable too. Moreover the number of images which should be analyzed is growing strongly due to technological advances. Hence, manual segmentation becomes less efficient in clinical operations. Human interpretation may not be produced suitable as well. Consequently intelligent tools are so essential to segment automatically. Therefor automatic segmentation is notable and important step to form tissues and ROIs in medical applications.

Fig. 1 shows the general scheme of MIA system. In this scheme, an image of interested region is acquired by the proper imaging device like MRI for soft tissues. Then it would be processed in the digital computer by the image processing unit facilitated by MIA tools. Image is exhibited

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to clinicians by a display devise like monitor finally. It's so beneficial if the system can report the result of analysis in the text format.

Automatic analysis of medical images needs many image processing techniques and also preprocessing operations like noise removal, image enhancement, edge detection and so on. Thus the image is ready to be analyzed after these preliminary steps are finished. Mining ROIs in the image is done in the segmentation phase through combination of intelligent methods then. Afterward feature extraction is performed to identify and recognize the ROI which may be a tumor, lesion, abnormality and so on. All these operations are done in the *processing* phase in Fig. 1.

In MIA, segmentation is required for more concentrations in later steps namely feature extraction, image measurement and ROI representation. Segmentation should be done correctly to obtain some determinant features of disease or subsequent lesion in MIA. Because by failing it, too many errors appear in feature extraction, image measurement and ultimately displaying image. A sample of segmentation for MRI heart image is shown in Fig. 2.

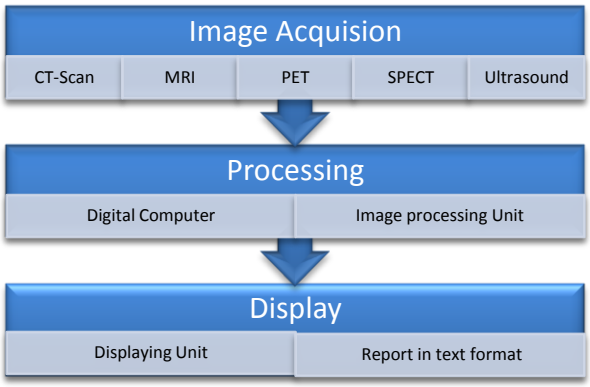


Fig. 1. General scheme for medical image analysis system

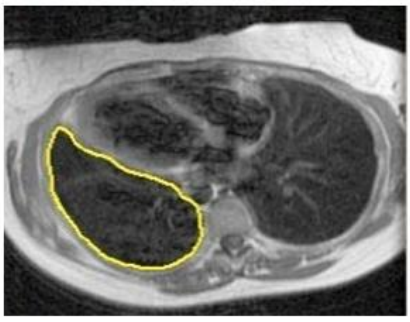


Fig. 2. A sample of segmentation of a MRI heart image

III. Problems of Segmentation

Some information is needed such as anatomy, physiology and organ functionality in diagnosis. Variant information leads to form variant modality for imaging devices. Variant modalities affect on the segmentation methods highly and complicate it too. In addition the significant growth of technology in medical imaging devices affects on applied methods for automatic analysis of medical images. So MIA methods should be up to date. This exigency covers the segmentation too. In addition of this necessity, following reasons make the MIS an obstacle and challengeable problem [1], [3], [8], [12] and [21]:

1) Variant shapes of ROI,
2) Image quality,
3) Definition of objective,
4) Variant modalities,
5) Dependency on type and complex visual characteristics of diseases,
6) Need to basic knowledge,
7) Failing the simple segmentation techniques like edge detection and thresholding for soft tissues,
8) Uncertainty in the boundaries of ROI,
9) Technique selection properly for an application,
10) Limitations of medical imaging devices,
11) Absence of vivo benchmarks,
12) Lack of ground truth,

Impossible comparison of available method in literatures.

IV. Application of Segmentation

Accurate analysis of massive medical datasets increases the request for their segmentation intensively as mentioned in section II. In general view, the main applications of MIS are *computer-aided diagnosis*, *computer-aided surgery* and *medical research* (study of anatomical structure). MIS can classify pixels into the anatomical regions like bone, muscle, blood vessel as well as into pathological regions such as cancer, tissue deformities and multiple sclerosis lesions. It's so useful in boundaries identification of ROI like different parts of brain [11], [22], distinct bones in the bony structures, tumors [22], microcalcification in the breast [23], prostate [21], iris [24], liver [25], lung [26] and so on. Likewise, many applications of MIS are as follow:

1) Therapy evaluation
2) Disease progress
3) Localization of tumors and other pathologies
4) Quantification and spanning of tissue volumes
5) Partial volume correction of functional imaging data (especially in PET, FMRI)
6) Monitoring surgery by images and surgical simulation [9]
7) Earning prior knowledge and prior model
8) Finding, visualization , simplification, classification, recognition, verification and retrieval of an ROI

V. Progress of Literature Number

Recent advances in processing and analysis of images and a growing interest in MIS have been published in many book chapters and articles like [1], [2] and [4]. Increasing growth in the number of chapters, books and articles shows that the topic of MIS is so regarded and significant as well as it has been remained a challengeable problem [2], [4]. In this section, the progress would be shown with the following charts in the eleven recent years by searching "*segment*" phrase on PUBMED, IEEE and Elsevier libraries.

The phrases "*segment*", "*image* and "*medical*" were searched together in the document title of literatures in the IEEE digital library by the authors and 979 literatures were totally found from the year 2000 till the end of 2010. The significant progress can be seen in the number of literatures by considering chart 1 and corresponding data.

Similar to IEEE digital library, in the Elsevier Journal publisher, the searching term is "*segment*" and "*medical*".

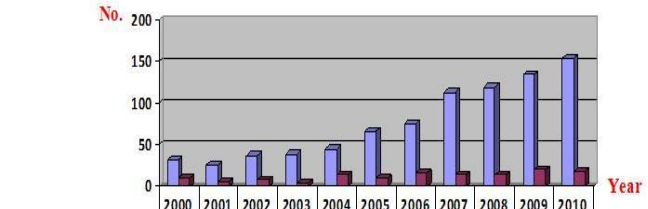
Entirely 125 literatures were found with obvious significant progress seen in the number of literatures dramatically in chart 2.

In PUBMED [1], US national library of medicine, "*segmentation*" is the term of search which results in 3408 literatures totally. The corresponding chart, i.e. chart 3, shows the notable increment in the number of literatures similar to chart 1 and chart 2.

It's should be noted that although progress of literature number shows the growing interest in this field, but it make difficult the innovation in this field unfortunately.

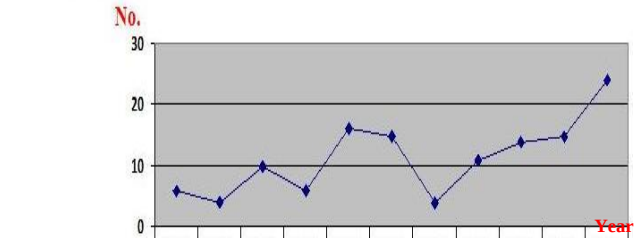
VI. Conclusion

In this paper, the segmentation phase in the MIA was explained first. Then some problems and applications of the segmentation were mentioned. Moreover, the progress carrier was shown and proved with some charts in the eleven recent years by searching "*segmentation*" phrase on PUBMED, IEEE and Elsevier libraries. These charts showed the high growing interest of research in the MIS fields. Furthermore they proved that the segmentation has been remaining a challengeable area.



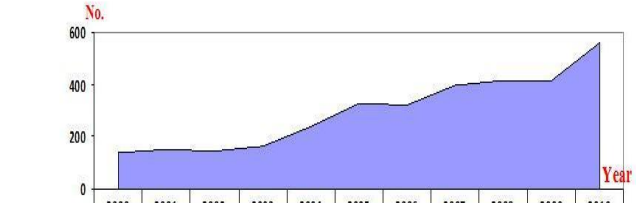
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
No. of conference paper	32	27	37	39	45	66	75	113	119	134	154
No. of journal paper	10	6	8	5	15	10	16	14	14	21	19

Chart 1. Progress of available literatures about MIS. (The terms "*segment*" and "*image* and "*medical*" were searched in the IEEE digital library and found 979 literatures from 2000 till the end of 2010 totally)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
No. of Journal Paper	6	4	10	6	16	15	4	11	14	15	24

Chart 2. Progress of available literatures about MIS. (The terms "*segment*" and "*image* and "*medical*" were searched in the Elsevier Journal publisher in the title of literatures and found 125 literatures from 2000 till the end of 2010 entirely)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
No. of literatures	137	151	145	162	242	329	319	397	419	420	562

Chart 3. Progress of available literatures about MIS. (The term "segmentation" in the title of literatures were searched in the PUBMED publisher and found 3408 literatures from 2000 till the end of 2010 entirely)

[1] http://www.ncbi.nlm.nih.gov/pubmed/

References

[1] Elsevier and I. Bankman, *Handbook of Medical Image Processing and Analysis*, 2nd ed., 2009, pp. 71-257.

[2] H. Zaidi, "Medical image segmentation Quo Vadis – comparison," *J. Elsevier Computer Methods and Programs in Biomedicine*, vol. 84, Issues 2-3, pp. 63—65, 2006.

[3] J. Melonakos, "Geodesic Tractography Segmentation for Directional Medical Image Analysis," Ph.D. dissertation, Dept. Elect. and Computer Engineering, Georgia Institute of Technology Univ., May 2009.

[4] D. J. Withey and Z. J Koles, "Three Generations of Medical Image Segmentation-Methods, Available Software," *International J. of Bioelectromagnetism*, vol. 9, no. 2, 2007.

[5] G. Harris, N. C. Andreasen, T. Cizadlo, J. M. Bailey, H. J. Bockholt, V. A. Magnotta, and S. Arndt, "Improving Tissue Classification in MRI: A Three-Dimensional Multispectral Discriminant Analysis Method with Automated Training Class Selection," *J. of Computer Assisted Tomography*, vol. 23, no. 1, 1999, pp. 144-154.

[6] M. Rastgarpour and J. Shanbehzadeh, "Application of AI Techniques in Medical Image Segmentation and Novel Categorization of Available Methods and Tools," Lecture Notes in Engineering and Computer Science: presented at 6th International Multiconference of Engineers and Computer Scientists, IMECS, Hong Kong, pp. 519-523, March 2011.

[7] M. Rastgarpour and J. Shanbehzadeh, "The Status Quo of Artificial Intelligence Methods in Automatic Medical Image," I*nternational Journal of Computer Theory and Engineering,* 2012-to be published.

[8] D. L. Pham, Ch. Xu and J. L. Princo, "a survey on current methods in medical image segmentation," *Annual Review of Biomedical Engineering*, vol. 2, pp. 315-337, 2000.

[9] L. P. Clarke, R. P. Velthuizen, M. A. Camacho, J. J. Heine, M. Vaidyanathan, L. Hall, R. W. Thatcher, and M. L. Silbiger, "MRI segmentation: Methods and applications," *J. of Magn. Reson. Imag*, vol. 13, pp. 343–368, 1995.

[10] M. S. Atkins and B. T. Mackiewich, "Fully Automatic Segmentation of the Brain in MRI. Medical Imaging," *IEEE Transactions on*, vol. 17, Issue 1, pp. 98-107, 1998.

[11] T. Cornelius and Leondes, "Medical Imaging systems technology: methods in cardiovascular and brain," Singapore, 2005.

[12] D. Yang, J. Zheng, A. Nofal, J. Deasy, and I. M. E. Naqa, "Techniques and software tool for 3D multimodality medical image segmentation," *J. Radiation Oncology Informatics*, vol. 1, no. 1, 2009.

[13] S. D. Olabarriag and A. W. M. Smeulders, "Interaction in the segmentation of medical images: A survey,". *Med.Image*, Anal., 2001, Elsevier, pp. 127-142.

[14] D. J. Withey and Z. J. Kole, "Medical Image Segmentation: Methods and Software," *IEEE in Proc. Of NFSI&ICFBI*, 2007, China, pp. 140-143,.

[15] A. Pitiot, H. Delingette, and P. M. Thompson, "Automated Image segmentation: issues and applications," *Ch. 6 of Medical Imaging Systems Technology: Methods in general anatomy (Medical Imaging Systems Technology*, Cornelius T. Leondes, 2005, vol. 3 pp. 195-241.

[16] N. Sharma and L. M. Aggarwal. *Automated medical image segmentation techniques, J. of medical physics*, pp. 3-14, 2010. [Online]. Available: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2825001/

[17] H. Nayak, M. M. Amini, P. T. Bibalan, and N. Bacon, "Medical Image Segmentation-report," 2009.

[18] E. Neufeld, T. Samaras, N. Chavannes, and N. Kuster. *Robust, Highly Detailed Medical Image Segmentation*. pp. 56-57, 2006 [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.11.116.4080&rep=rep1&type=pdf

[19] H. Nayak, M. M. Amini, P. T. Bibalan, and N. Bacon, "Medical Image Segmentation-report," 2009.

[20] J. C. Souplet. *Medical Image Navigation and Research Tool by INRIA (MedINRIA)* pp. 1-57, October 2009, [Online]. Available: http://www.sop.inria.fr/asclepios/software/MedINRIA/doc/usermanual/MedINRIA.pdf.

[21] L. Xin, D. L. Langer, M. A. Haider, Y. Yang, M. N. Wernick and I. S. Yetik, "Prostate Cancer Segmentation with Simultaneous Estimation of Markov Random Field Parameters and Class," *IEEE Trans. On medical imaging*, vol. 28, issue 6, pp. 906-915, 2009.

[22] M. Prastawa, E. Bullitt, N. Moon, K. V. Leemput, and G. Gerig, "Automatic brain tumor segmentation by subject specific modification of atlas priors," *Academic Radiology* 2003, vol 10, pp. 1341-1348.

[23] M. Kowal and J. Korbicz, "Segmentation of Breast Cancer Fine Needle Biopsy Cytological Images Using Fuzzy Clustering," *in*

Proceedings of Advances in Machine Learning I., 2010, Springer, vol. 262, pp. 405-417.
[24] H. Proenc, "Iris Recognition-On the Segmentation of Degraded Images Acquired in the Visible Wavelength," *IEEE Trans. Pattern Analysis and Machine Intelligence*, 2010, vol. 32, issue 8, pp. 1502-1516.
[25] P. Campadelli, E. Casiraghi, and A. Esposito, "Liver segmentation from computed tomography scans: A survey and a new algorithm," *J. of Artif Intell Med*, 2009, vol. 45, issue 2, pp. 185-196.
[26] C. Lei, L. Xiaojian, Z. Jie, and C. Wufan, "Automated lung segmentation algorithm for CAD system of thoracic CT," *J. Medical Colleges of PLA*, 2008, vol. 23, issue 4, pp. 215-222.

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