iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1437

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

A Comparative Analysis on the Dental X-ray Image Segmentation Approaches

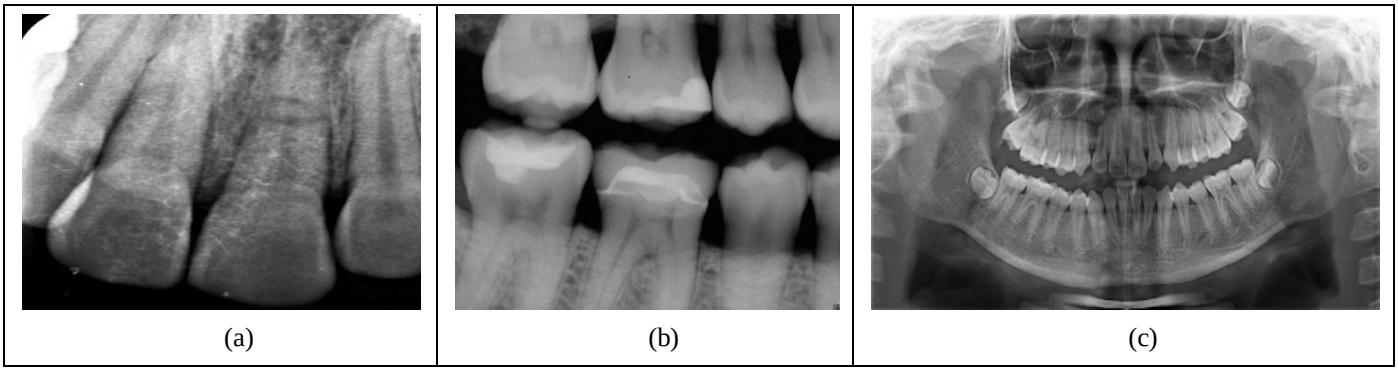
Ritu Bala[1], Divjot Kaur[2]
[1, 2] *Department of Computer Science and Engineering, Rayat Institute of Engineering & Information Technology, Railmajra, Punjab, India*

Abstract: ***In Scientific research, radiography/x-ray images have attracted the researchers to work due to its wide range of applications in medical, forensic, dental and other health diagnosis. Dental x-ray images are used to detect the dental problems like tooth decay, cavity problem and other periodontitis diseases. These dental problems can only be detected after the segmentation of dental x-ray images. Segmentation of dental x-ray image is indispensable step while detection of periodontitis diseases. Dental x-ray segmented images can be further used for the applications of dental plague, dental age, human identification after post-mortem, forensic science. Due to this huge list of applications of segmented dental x-ray images, the methods used to segment dental x-ray images should be appropriate and efficient. In this paper, a comparative review on the dental x-ray image segmentation is presented along with the discussion on use of method, key features, dataset and evaluated results.***

Keywords: Image Segmentation, Dental X-ray, Dental Diagnosis, Teeth Structure, X-ray, Dental Diseases

I. INTRODUCTION

Dental x-ray are the grayscale level captured images of human teeth and surrounding parts like jaws, bones & other soft tissues [1] [2]. X-ray images capture the detailed grayscale image that helps to find hidden cavities, overlapped teeth structure, gap between internal root teeth, bone decay etc [3]. There are three types of methods available to capture dental x-ray. These methods are periapical, bite-wing and panoramic dental x-ray [4] [5]. Periapical x-ray is the x-ray of complete tooth from the outer crown to teeth structure along with bones, roots and gum information. Dentist generally performs the periapical x-ray during the first visit of patient. These x-rays are helpful to detect the problem in the jaws and below the gum lines like damaged bone, small tumors, impacted teeth etc. Bite-wing dental x-ray is the grayscale x-ray of the lower and upper back teeth. This helps to detect the problem of tooth decay along with the information that whether lower teeth are properly line up with the upper teeth or not. Bite-wing x-ray is also useful for the detection of bone loss due to dental infection or gum disease. Panoramic dental x-ray is the x-ray of broad internal structure of mouth including information of jaw points, nasal area, sinuses, teeth and jaws. Panoramic x-ray is useful for the detection of oral health of a person. Also, it is useful to show problems like dental caries, fractures, small tumors, cysts, bone abnormalities and impacted teeth. A sample of these three types of dental x-ray images is shown in fig. 1.



(a) (b) (c)

Fig. 1: Types of Dental X-ray (a) Periapical Dental X-ray, (b) Bite-wing Dental X-ray, (c) Panoramic Dental X-ray

These x-rays images are considered as input to obtain the segmented image. Segmentation of image is the most essential and important step while detection of any disease in the teeth and surrounding surfaces. The major use of image segmentation is for the applications of image matching and pattern recognition. Image segmentation is not an easy to make process among the image processing steps. Segmentation is the process of extraction of region of interest by partitioning an image into different possible

regions. In dental x-ray image, segmentation is performed to divide the image into three regions as mentioned: background region, dental structure region and teeth region [6]. Background region illustrates the background of teeth structure having lower brightness level of grayscale pixels. Dental structure region shows periodontitis structure along with the information of bone and gums. Dental structure level has intermediate brightness level of grey scale pixels. Teeth region is the required region of interest for the diagnosis of any dental disease. Teeth region is the brightest region of the grayscale pixel image. This teeth region is further used for the applications. So, segmentation is the essential step for the diagnosis of any dental disease/problem.

Segmentation of dental x-ray images is an exacting task as compare to other medical x-ray images due to the presence of challenges like space in between two missing tooth, tooth variations, impacted teeth and artifact sample etc. There are various existing concepts and approaches for dental image segmentation. Most of the work is presented on the medical images with different body parts. But this paper focuses on the review of dental x-ray image segmentation. The comparative results of these authors are analyzed based on the used method, evaluation and key features.

Rest of the paper is organized in the following manner: Section 2 presents the dental image segmentation approaches based on region, edge and pixel. Section 3 presents the work related to dental image segmentation and Section 4 concludes the paper along with some future directions.

II. DENTAL IMAGE SEGMENTATION APPROACHES

There is the availability of mainly three types of approaches for the segmentation of images as mentioned: Region based, Edge based and Pixel based. Region based approaches depends upon the pattern and intensity matching of a region with neighboring pixels within that cluster. Edge based segmentation is to separate the region based on the discontinuity of the image pixel and intensity values from neighboring pixels. Pixel based segmentation is the separation of image region based on the grey level pixel values of image. This classification is shown in fig. 2.

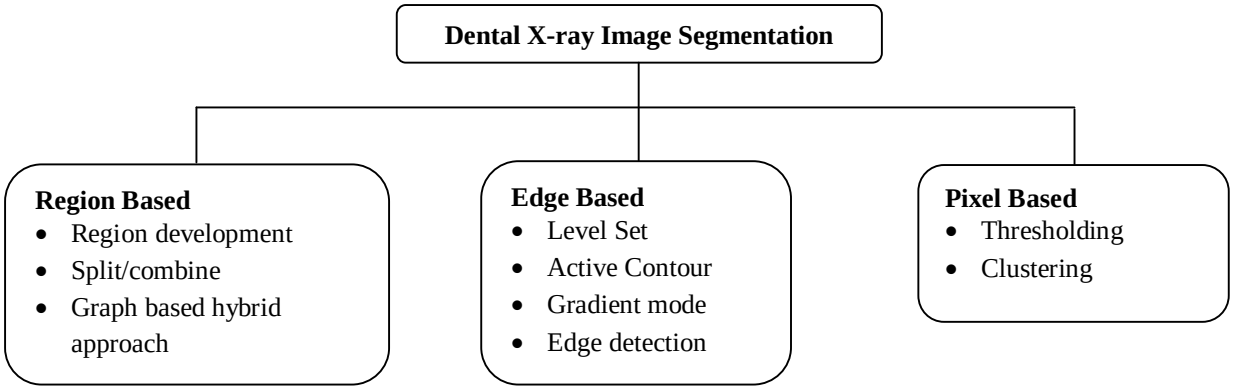


Fig. 2: Different Types of Dental x-ray Image Segmentation

III.LITERATURE REVIEW

This section presents the dental image segmentation approaches considered by different authors along with the comparative results shown in table 1.

Kumar et al. (2011) [7] have performed the dental image segmentation on 3D models and generate an autonomous system for segmentation. These imagery models are laser scanned 3D models of 26 orthodontic patients. In manual separation of teeth region from other sections is a time consuming and erroneous concept. So, there is the need of some autonomous approach that initially separate the gums from teeth and then teeth are individually separated from each other. Here, authors first classified the teeth from gums from the mesh and then tooth are individually separated 3D boundary curves between the neighboring teeth. Authors have implemented the concept in C++ language based software. The overall use of this software technique is to reduce the human intervention in tooth segmentation process. This method overcomes the limitations of the existing work as existing approaches use morphological operations with feature extraction which generates problems due to scanning errors and flat gum-lines. Authors overcame this problem by initially separating the teeth from gums and individual tooth-tooth separation.

Modi and Desai (2011) [8] have proposed the novel segmentation approach of binary edge intensity integral curves for the detection of tooth isolation and gap valley from dental x-ray images. Algorithms of canny edge detection and region growing approach are used to find these curves. As dental image segmentation is demanding problem due to variation in intensity and noise value. So,

ROI is extracted with the addition of some morphological operation and filter values. Authors have performed the experiments on 30 dental radiography images and evaluated the results with ROI of 83% dental images. The considered approach clearly isolates the tooth regions from bones with a clear segmentation of lower and upper jaws. The algorithm also clearly indicates the ROI with higher region of gap valley in case of extra gap valley tilt.

Vinh et al. (2013) [9] have considered the embedded system design for the segmentation of dental images with the use of active contour without edges method. The process involves the steps to capture the dental images, dental images pre-processing to enhance contrast & brightness etc of the teeth image, teeth segmentation and finally maintains of record of patients & diagnosis note of doctor. Here, Weiner filter is used for the removal of Gaussian noise from the dental image. There is also the involvement of some computational steps to remove extra dilation and blob region expansion. In this embedded system, ARM is used with S3C2440 microprocessor and GUI for user interface. This real time based system is ready for the dental use and moreover it can be used for home.

Wu et al. (2014) [10] have presented a morphological skeleton for the segmentation of scanned dental meshes. The considered concept has significant feature benefits of robustness to teeth crowding problem, teeth irregularities & different teeth shapes. It is not only efficient to implement but also reduces the user interaction. The steps of dental mesh model segmentation involves the steps of removal of base from complete mesh, extraction & improvement of boundaries from teeth with some gums, teeth separation and contour modeling for final extraction & segmentation. For experimentation, 56 dental mesh segments are considered and demonstrated for the different levels of teeth crowding problem. There are three types of crowding as mentioned: severe, moderate and mild. Authors have evaluated the results with three parameters of user interaction, error rate and time consumption. Authors have evaluated the average time conception of 10secs or lesser for each segmentation experiment. The mean error rate is also lesser than 0.16mm which is clinically acceptable standard. In case of user interaction, seed point addition and boundary completion are considered having time consumption of 10 sec and 30 sec respectively. The main limitation of concept is that there is need to add more user interaction in case of noise value.

Kaur and Singh (2015) [11] have used the k-means clustering algorithm for the dental image segmentation. Authors have discussed various dental issues along with the basic tooth structure. Authors have also discussed the clinical tools available for dental image segmentation along with the statistical and computer based feature extraction approach. The main focus of authors are on the detection of dental caries by following the steps of selection of region of interest, color component conversion, clustering algorithm and evaluation of tooth surface suffered on dental caries. Concept is also presented with some feature extraction and spatial lustering approaches and presented the results with some cases of segmentation of dental x-ray images.

Liao et al. (2015) [12] have presented a harmonic field based approach for the autonomous segmentation of dental x-ray mesh model into individual teeth. The considered concept of harmonic field uses the prior knowledge strategy for shape extraction and weighing scheme for the smoothness extraction and overall performs automatic dental teeth segmentation. The considered concept is insensitive to noise and robust to tooth crowd problems, malocclusion & different tooth structures. It also guarantees the extraction of accurate boundary values from dental mesh and concept is automatic with no user interference after initialization. Experiment is performed on 60dental mesh laser scanned models of lower & upper jaws and evaluated segmentation approach in terms of time consumption and mean error rate.

Amer and Aqel (2015) [13] have proposed segmentation algorithm for the extraction of wisdom teeth from the panoramic dental images. This approach detects the wisdom teeth information along with their deviation and structure. With this information, it can be declared about the wisdom teeth that it is completely erupted, partially erupted or with a minor impact. Authors have divided the approach in three steps of pre-processing, Extraction of ROI and Post-processing. Pre-processing involves the steps like contrast enhancement, teeth threshold extraction, morphological dilation, connected component labeling, removal of unwanted objects, image multiplication etc. Extraction of ROI from panoramic image with separation of lower & upper jaws, removal of zero pixel parts and applies four masks to separate four wisdom teeth. Post processing involves the steps of histogram equalization, threshold teeth separation, morphological operation, removal of unwanted regions and image multiplication. Authors has evaluated and compared the considered concept in terms of mean absolute error and percentage possibility of automation of system.

Ali et al. (2015) [14] have used Active Contour without edges approach for the segmentation of dental x-ray images. Authors have performed this Chan-Vese model on the GPU and compared with CPU in terms of processing speed. Experiment was conducted on four medical datasets with image size of 2653*2336, 888*495, 500*375 and 131*131. Comparison was made with different iteration number of 50, 500, 500 and 2000. From the comparative results of serial CPU and CUDA GPU; GPU performs better as compare to CPU in terms of processing speed and time.

Hasan et al. (2016) [15] have used Gradient Vector Flow (GVF) snake approach for the segmentation of panoramic dental x-ray images. This process involves the steps of k-means clustering, thresholding& key point detection around jaws, initialization of suitable points for GVF approach, perform segmentation with the mentioned approach and correction of segmented area by making its oval shape. This oval shape segmentation is important step to consider wisdom teeth while segmentation. Experimentation is performed on 284 images having resolution of 256*512 grayscale pixels. Without the correction step, proposed approach only segments the 76% images but with oval shape segmentation correction, this step has been improved to 92%. Authors have also evaluated the average execution time for segmentation as 6.7 seconds.

Tuan et al. (2016) [16] have proposed semi supervised fuzzy clustering algorithm for the segmentation of dental x-ray images. This concept is based on the interactive fuzzy satisficing and use the prior membership function of eSFCM to generate a novel objective function. There is the involvement of three subsections in objective function as mentioned: information related to membership matrix, spatial information and Standard FCM. Authors have considered the evaluation parameters of Davies-Bouldin, PBM and IFV for the analysis of results. Experimental dataset consist of 56 dental x-ray images taken from the Hanoi Medical University for the year 2014-2015. Proposed concept is compared with FCM, Otsu, eSFCM, SSCMOO, FMMBIS, SSFC-SC and analyzed better performance for the proposed SSFC-FS approach.

TABLE I
COMPARATIVE ANALYSIS OF DENTAL IMAGE SEGMENTATION APPROACHES

Author and Year	Approach/Method used	Dataset Considered	Analysis
Kumar et al. (2011)	Tooth-Gum Separation and Tooth-tooth Separation	laser scanned 3D models of 26 orthodontic patients	• Used 3D models instead of 2D dental images. • Overcomes the limitations of existing concepts to use morphological operations with feature extraction.
Modi and Desai (2011)	Binary Integrated Edge Intensity Curves	30 Dental X-Ray images	• Canny edge detection and region growing approach are used to find ROI curves. • Detected ROI (tooth isolation and gap valley) for 83% of the images.
Vinh et al. (2013)	Active Contour Without Edge	Not Described	• Considered embedded system with active contour without edges for dental image segmentation. • Available for the use in Real world dental problem.
Wu et al. (2014)	Morphological Operation	56 dental mesh models	• Significant feature benefits of robustness to teeth crowding problem, teeth irregularities & different teeth shapes. • Concept is limited valid in case of higher noise value.
Kaur and Singh (2015)	K-means Clustering	Not Described	• Presented dental segmentation using k-means clustering to detect dental caries.
Liao et al. (2015)	Harmonic Field based approach	60 laser scanned Dental mesh models	• Harmonic field uses the feature of prior knowledge extraction and weighing scheme. • Evaluated with optimum mean error rate and time consumption.
Amer and Aqel(2015)	Self Defined Approach	Panoramic dental images	• Lower mean absolute error as compare to other existing approaches. • Considered concept is fully automated as compare to other approaches.
Ali et al. (2015)	Active Contour Without Edges	Four medial image dataset	• GPU based dental x-ray image segmentation is performed. • Proposed GPU approach shows better comparative results as compare to CPU

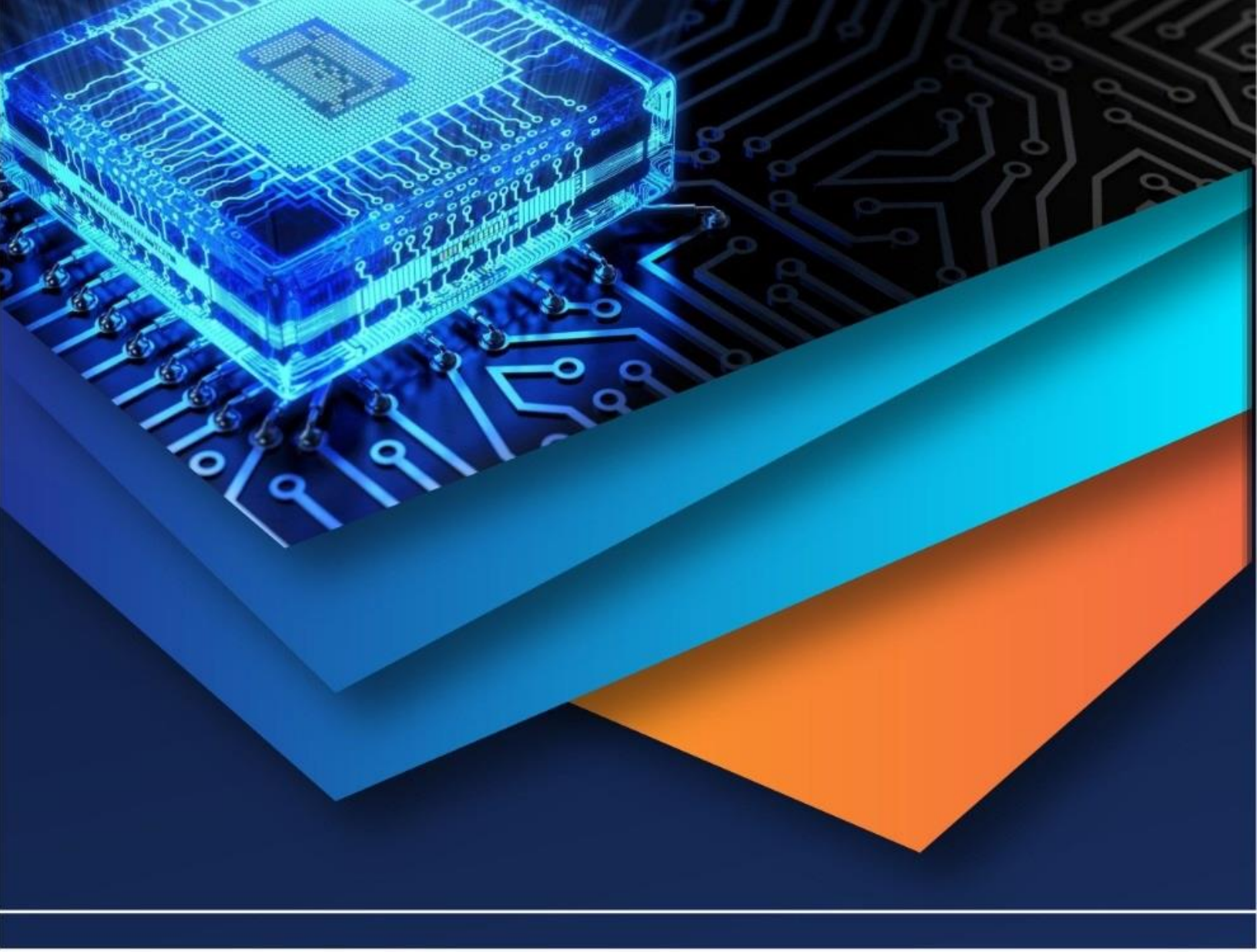
			system.
Hasan et al. (2016)	Gradient Vector Flow (GVF) snake approach	284 Dental panoramic Images	• Introduced the correction step of oval shape segmentation to improve the segmentation possibility. • Evaluated average execution time of 6.7sec for segmentation.
Tuan et al. (2016)	Semi-supervised fuzzy clustering algorithm	Hanoi Medical University Dataset (56 Dental x-ray images)	• Comparative better results as compare to FCM, Otsu, eSFCM, SSCMOO, FMMBIS and SSFC-SC.

IV. CONCLUSIONS

As discussed, segmentation of dental x-ray images is an essential step for the detection or analysis of any disease related to teeth and gums. In this paper, we have presented a comparative analysis on the approaches available for dental image segmentation. An initial discussion on the basic available methods of image segmentation is presented. Further, different methods used by different authors for dental image segmentation are also discussed. The considered approaches are tooth-gum separation, tooth-tooth separation, binary integrated edge intensity curves, active contour without edges, morphological operation, k-means clustering, harmonic search, gradient vector flow snake approach and semi supervised fuzzy clustering algorithm. Most of the authors have used dental mesh models, panoramic dental images and some other expert dental 2D images. From the comparative analysis, it can be evaluated that segmentation of dental x-ray images still need improvement for the real-world application to diagnose dental diseases and problems.

REFERENCES

[1] Said, Eyad Haj, DiaaEldin M. Nassar, GamalFahmy, and Hany H. Ammar. "Teeth segmentation in digitized dental X-ray films using mathematical morphology." IEEE transactions on information forensics and security 1, no. 2 (2006): 178-189.
[2] Molteni, Roberto. "Direct digital dental x-ray imaging with Visualix/VIXA." Oral surgery, oral medicine, oral pathology 76, no. 2 (1993): 235-243.
[3] Wildenschild, Dorthe, and Adrian P. Sheppard. "X-ray imaging and analysis techniques for quantifying pore-scale structure and processes in subsurface porous medium systems." Advances in Water Resources 51 (2013): 217-246.
[4] Li, Shuo, Thomas Fevens, Adam Krzyżak, and Song Li. "An automatic variational level set segmentation framework for computer aided dental X-rays analysis in clinical environments." Computerized Medical Imaging and Graphics30, no. 2 (2006): 65-74.
[5] Zhou, Jindan, and Mohamed Abdel-Mottaleb. "A content-based system for human identification based on bitewing dental X-ray images." Pattern Recognition 38, no. 11 (2005): 2132-2142.
[6] Scott, James Henderson. "Introduction to dental anatomy." (1977).
[7] Kumar, Yokesh, Ravi Janardan, Brent Larson, and Joe Moon. "Improved segmentation of teeth in dental models." Computer-Aided Design and Applications 8, no. 2 (2011): 211-224.
[8] Modi, Chintan K., and Nirav P. Desai. "A simple and novel algorithm for automatic selection of ROI for dental radiograph segmentation." In Electrical and Computer Engineering (CCECE), 2011 24th Canadian Conference on, pp. 000504-000507. IEEE, 2011.
[9] Vinh, Truong Quang, Bui Minh Thanh, and Nguyen Ngoc Tai. "Dental intraoral system supporting tooth segmentation." In Computing, Management and Telecommunications (ComManTel), 2013 International Conference on, pp. 326-329. IEEE, 2013.
[10] Wu, Kan, Li Chen, Jing Li, and Yanheng Zhou. "Tooth segmentation on dental meshes using morphologic skeleton." Computers & Graphics 38 (2014): 199-211.
[11] Kaur, Jagdeep, and Jatinder Singh. "An Image Segmentation Based Clustering Technique Applied on Dental Images." International Journal Of Emerging Technologies in Engineering Research (IJETER), ISSN-2454-6410 3: 1-4.
[12] Liao, Sheng-hui, Shi-jian Liu, Bei-jiZou, Xi Ding, Ye Liang, and Jun-hui Huang. "Automatic tooth segmentation of dental mesh based on harmonic fields." BioMed research international 2015 (2015).
[13] Amer, Yusra Y., and Musbah J. Aqel. "An Efficient Segmentation Algorithm for Panoramic Dental Images." Procedia Computer Science 65 (2015): 718-725.
[14] Ali, Ramzi Ben, RidhaEjbali, and MouradZaied. "GPU-based segmentation of dental X-ray images using active contours without edges." In Intelligent Systems Design and Applications (ISDA), 2015 15th International Conference on, pp. 505-510. IEEE, 2015.
[15] Hasan, MdMosaddik, Waidah Ismail, Rozita Hassan, and Atsuo Yoshitaka. "Automatic segmentation of jaw from panoramic dental X-ray images using GVF snakes." In World Automation Congress (WAC), 2016, pp. 1-6. IEEE, 2016.
[16] Tuan, Tran Manh, and Tran ThiNgan. "A novel semi-supervised fuzzy clustering method based on interactive fuzzy satisficing for dental x-ray image segmentation." Applied Intelligence 45, no. 2 (2016): 402-428.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY