Chapter 45
Image Segmentation Using Contour Models: Dental X-Ray Image Segmentation and Analysis

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ABSTRACT

Image segmentation is an important task in image processing, which is widely used in medical applications such as abnormality detection and after treatment progress monitoring. Conventionally, texture, region, and edge information are used for segmentation. Recently, the majority of image segmentation uses contour-based models. The problem of efficient segmentation in medical images is of great importance in disease diagnosis. Medical images suffer from weak boundaries, and placement of initial contour is a major issue. Level method is an effective method for segmentation of image as it has ability to tackle complex geometries. It helps to detect the precise location of the target region and help to prevent the boundary leakage problem. This chapter presents an overview of the advanced region and edge-based level set segmentation algorithms and their application in the dental x-ray images. Computer-aided diagnosis from x-ray images are of interest to clinicians in detection and accurate decision making. Case studies of multiple region segmentation from dental x-rays are presented.

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INTRODUCTION

Computer aided diagnosis system based on X-Ray images is significant to make accurate decision of diseases and therapeutic interventions (Son, 2018). X-ray technique is cheaper, widely used by radiologist, easily accessible electronically and has lower radiations compared to CT scan. A dental X-ray image consists of teeth area, dental structural area with bone, soft tissues and background area (Son & Tuan, 2016). They play a significant role in detection of periodontitis, root fracture, bone loss, oral cancer and carries that is difficult to be seen by a visual dental examination (Jain & Chen, 2004). Periodontitis results from the progression of gingivitis, which involves the inflammation and infection of the ligaments and bones that support the teeth. The jaw bones such as mandible and maxilla suffer from odontogenic lesions (Rajendran, 2009). Caries is caused by specific type of bacteria that destroys tooth enamel and layer underneath it. Prolonged bone loss and root decay may lead to tooth loss or erosion of the jaw bone. If bone loss and root decay are detected at an early stage, a suitable remedy can be provided by appropriate dental procedures such as root canal treatment.

One of the most interesting applications of dental X-rays is forensic identification and age estimation (Babshet, 2010; Jain, 1999; Zhou & Mottaleb, 2005). It is used in human identification system (Chen & Jain, 2004; Fahmy, 2004). In forensic dentistry, post-mortem and ante-mortem dental records are compared to confirm the identity of an individual (Pretty & Sweet, 2001). Dental images can be classified into bitewing, periapical, and panoramic views. Conventionally the teeth and the bones were segmented in the bitewing view. Further, each tooth is separated into crown and root, and the contours of the teeth are stored in the database to identify victims. The extraction of root is challenging than crown as it overlaps with the jaws due to lower difference in tissue density (Cavalcanti, 1999; Goaz & White, 1982). Each tooth can be classified into different types such as molar, premolar, canine and incisor (Lin, 2010). Wisdom tooth is an extra tooth and commonly affects other teeth while eruption (Nelson & Ash, 2010). Dental development based methods are applicable to age estimation for individuals under 21 years of age (Gustafson, 1950; Kvaal, 1995; Shahin, 2013).

There are certain challenges in the manual inspection of dental X-rays by dentists such as: expensive, requires specialized training, inter-observer variability and non-quantitative measurement (Jain, 2003). Segmentation is the initial task in the field of medical image processing, as the segmented regions are essential for diagnosis of disease pathology (Zhou, 2017). Dental X-ray image segmentation is absolutely necessary to analyze these images in order to obtain valuable information regarding the medical diagnosis and other recognition system (Said, 2004). The segmentation of dental X-rays is challenging due to noise, low contrast, sample artifacts, complicated topology and weaker boundaries between teeth. In addition, the segmentation of these images are difficult due to partial volume effect, intensity inhomogeneity and noise (Chen, 2012).

Appropriate enhancement techniques can be applied to dental radiographs that suffer from low contrast and uneven exposure to reduce the complexity involved in the segmentation task. Suitable morphological operations can be performed to enhance the contrast of the image that makes the teeth regions brighter and suppresses the intensity in the bone and the background regions (Gonzalez & Woods, 2008). The dental images were enhanced using morphological processing and wavelet transformation was used for segmentation (Patanachai, 2010). Edge extraction is essential for root canal treatment (Gayathri & Menon, 2014). Intensity inhomogeneity occurs due to imperfections in image acquisition (Dhawan, 2011). Hence bias correction can be carried out separately or interleaved with segmentation. Thus, there is a need for accurate and efficient algorithm to perform segmentation of dental X-rays to allow