

Segmentation of facial bone surfaces by patch growing from cone beam CT volumes

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INTRODUCTION

Precise planning of dental implants, and dental and maxillofacial surgeries requires volumetric images from the area to be operated. Cone beam computerized tomography (CBCT) has been developed as a relatively low cost and low dose alternative to conventional CT to meet these needs. During the last decade CBCT has become an established radiologic technique in dental imaging. Robust segmentation method for the bone-soft tissue boundary for facial bones would smoothen the clinical workflows.

Objectives

The goal of this work was to design an automatic algorithm capable of segmenting the exterior of the dental and facial bones including the mandible, teeth, maxilla and zygomatic bone with an open surface (a surface with a boundary) from CBCT images for the anatomy-based reconstruction of radiographs. Such an algorithm would provide speed, consistency and improved image quality for clinical workflows, for example, in planning of implants.

Methods

We used CBCT images from two studies: first to develop ($n = 19$) and then to test ($n = 30$) a segmentation pipeline. The pipeline operates by parameterizing the topology and shape of the target, searching for potential points on the facial bone-soft tissue edge, reconstructing a triangular mesh by growing patches on from the edge points with good contrast and regularizing the result with a surface polynomial. This process is repeated for convergence. The process is illustrated in Figure 1.

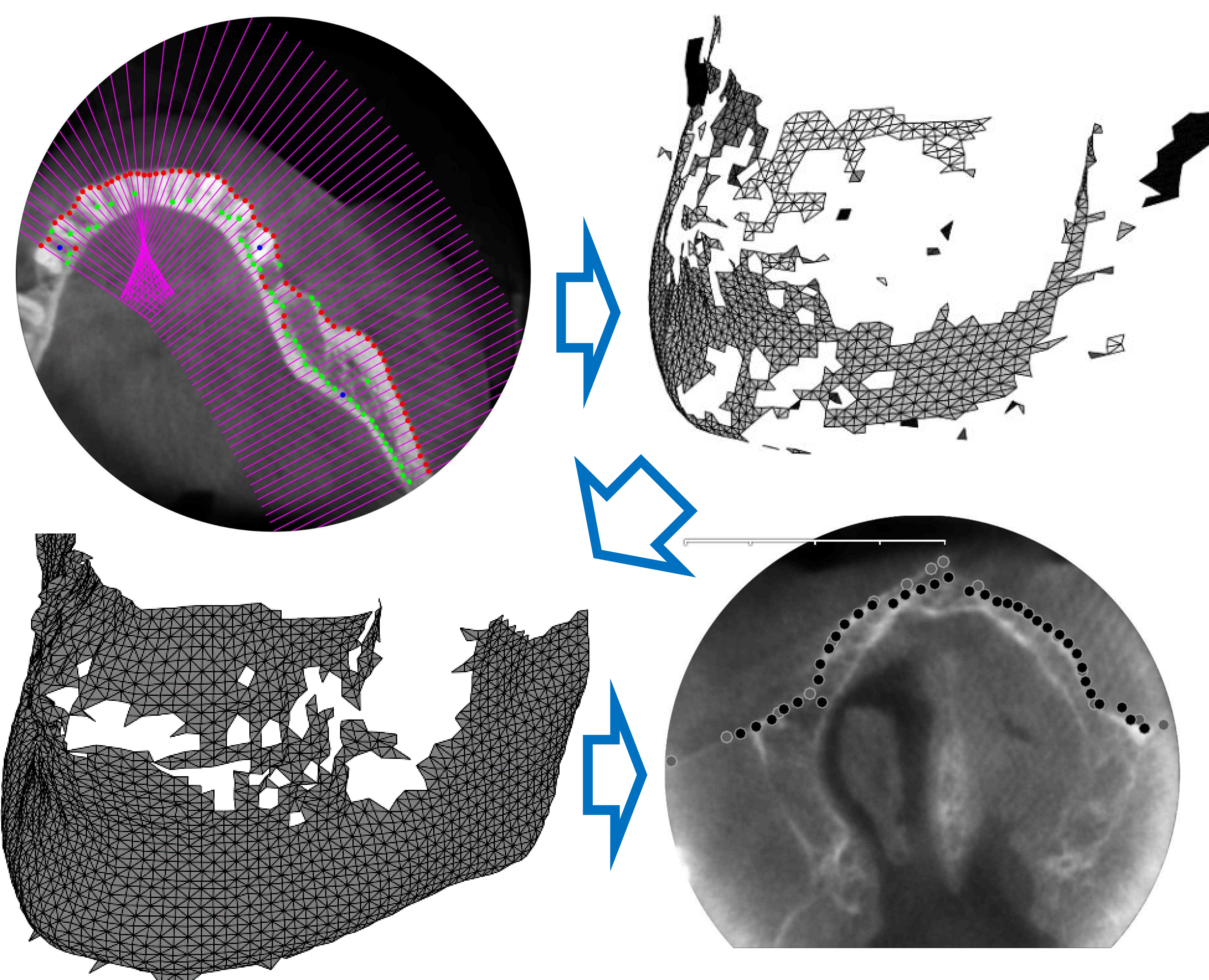


Figure 1. Steps of the segmentation process

RESULTS

The output of the algorithm was benchmarked against a hand-drawn reference and reached a 0.50 ± 1.0 -mm average and 1.1-mm root mean squares error in Euclidean distance from the reference to our automatically segmented surface. These results were achieved with images affected by inhomogeneity, noise and metal artefacts that are typical for dental CBCT. An example of a rendering done based on the result of segmentation is presented in Figure 2.

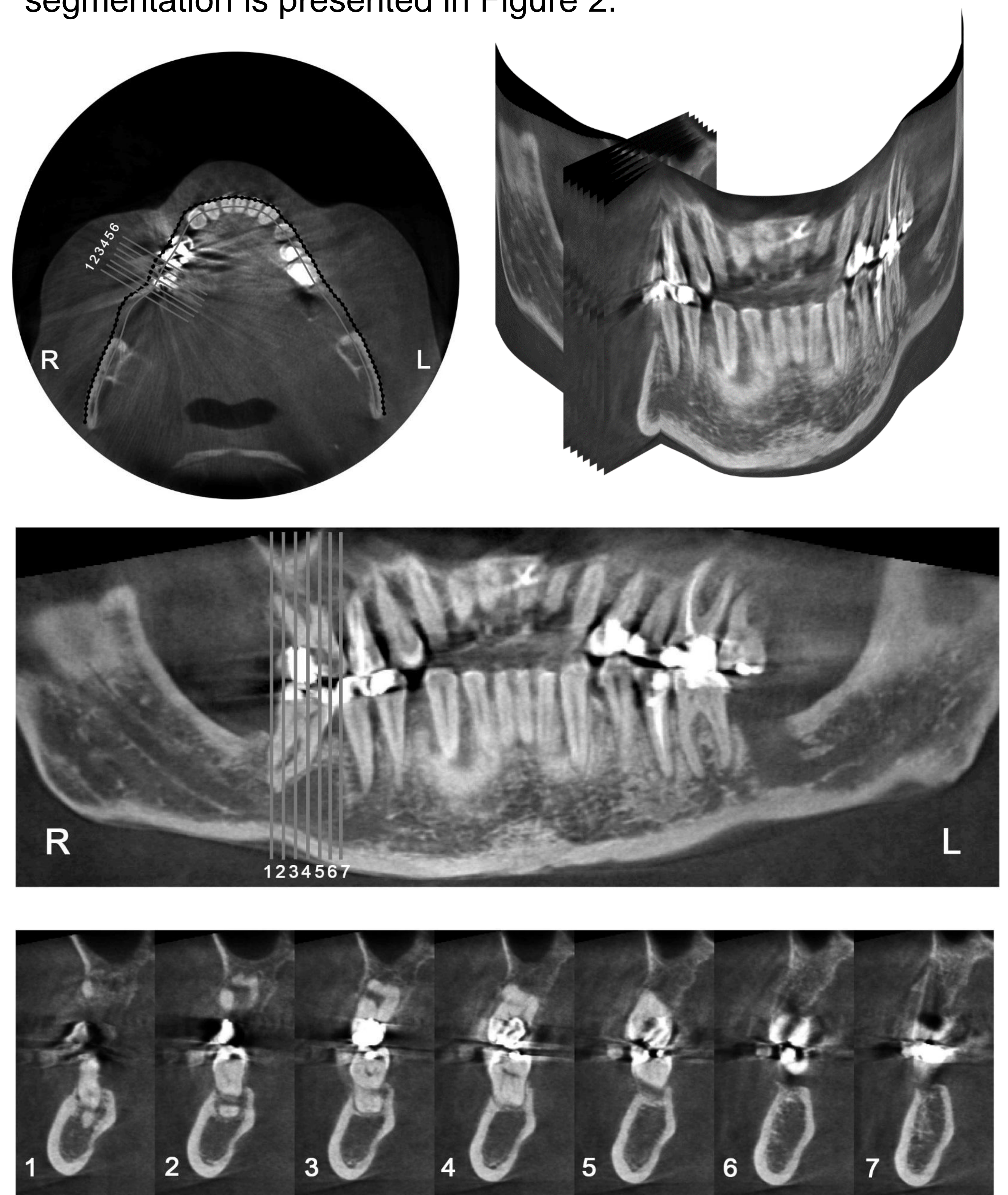


Figure 2. A rendering of views to a mandible based on the result of segmentation.

A more detailed description of the work is available at <http://dx.doi.org/10.1259/dmfr.20150435>

Conclusions

Previously, this level of accuracy and precision in dental CBCT has been reported in segmenting only the mandible, a much easier target. The segmentation results were consistent throughout the data set and the pipeline was found fast enough (< 1 -min average computation time) to be considered for clinical use.

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