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Multimodal 3D-Reconstruction of Dental Anatomy based on CT and DVT

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Introduction

In-silico studies about the mechanical properties of the mandible (e.g., [1]) and other applications require a segmentation of structures barely visible in conventional CT images. In particular, the PDL, a thin, fibrous ligament that connects the tooth to the bony socket, has a thickness (0.2 mm) close to or even below the resolution of a CT device. In addition, clinical data is often degraded by e.g. shaky patients. While this is true for DVT images as well, it is found that especially the gap between tooth and socket, occupied by the PDL, has a much better visibility in this images (Fig. 1). Consequently, the present work uses a DVT image series for segmentation of the PDL. As several artefacts can still be found in the data, an interactive segmentation is required.

Material and Methods

CT and DVT recordings at a resolution of 0.25 x 0.25 x 0.3 mm^3 and 0.125 x 0.125 x 0.125 mm^3 per voxel respectively were taken from a female subject. The subject was jittery during both recording sessions, which led to a severe degradation of the image quality in terms of spatial resolution. The free image processing software Image/J [2] was used in conjunction with a graphics tablet (Wacom Technology Corporation, Vancouver, USA) for all voxel based processing steps. The Amira Software (Mercury Computer Systems, Berlin, Germany) was used for image registration, 3D-modeling, and visualization of the result. First, a rigid landmarks based image warping and interpolation of the CT stack was performed according to the DVT stack using Amira. The PDL segment has been extracted from the DVT series by use of a graphics tablet and a range of Image/J tools. It turned out to be necessary to work out the PDL in different views of the stack i.e., the buccal, labial, and coronal views. After masking the DVT image stack with this segment, the tooth could be segmented by a simple thresholding algorithm. False positive segments were removed by means of a volume fill algorithm that has been developed for this purpose and implemented as a plugin to Image/J. The surface of the tooth was manually refined afterwards. In the last segmentation step, tooth and PDL were masked in the CT image series to isolate the cortical bone with a global thresholding algorithm. Interactive refinements were done in order to remove all remaining false positive voxels. Finally, all segments were polygonized and smoothed by means of Amira.

Results

Figure 1: The DVT data series shows a gap (indicated by white arrows) between tooth and socket which indicates the location of the PDL.

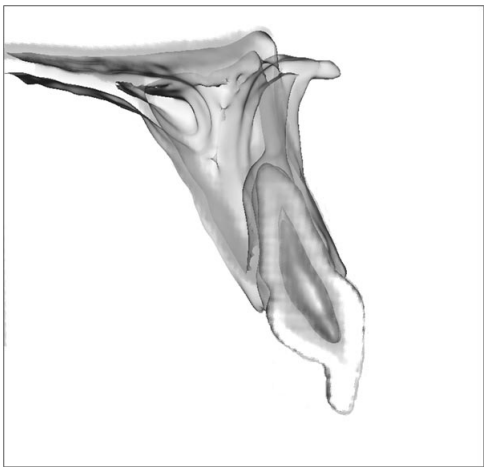

Figure 2: Buccal view of the polygonized cortical bone, clipped visualization with CT data (tooth) superimposed in transparent rendering.

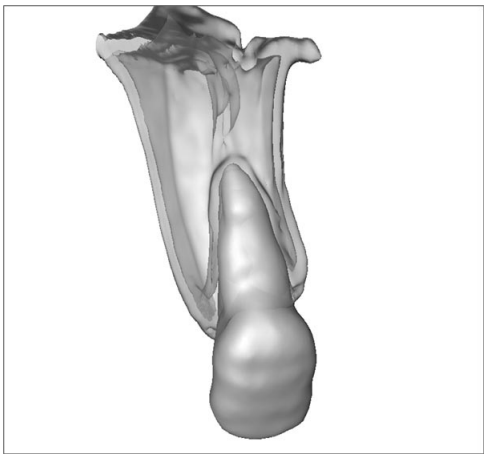

Figure 3: Labial view of the polygonized tooth and cortical bone.

Fig. 2 and 3 show the polygonized segments of tooth and cortical bone in buccal and labial view respectively.

Conclusions

Although DVT images show a variety of artefacts [3] which make them less appropriate for structural studies, they turned out to be helpful in a situation where the PDL couldn't be identified in a conventional CT. By a combination of both imaging techniques - image warping and masking - it was possible to extract valuable information about the tooth and its socket that couldn't have been found in one of the image stacks alone. Furthermore, the comparison of DVT and CT images allows detailed insights in possible degradations of DVT images and may help further evaluation of this image acquisition technique.

Literature

1. Kober et al., Finite Element Simulation of the Human Mandible: The Influence of the PDL on its Structural Behaviour, SGKG Basel, 2005
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This Poster was submitted by Dr. Thomas Radtke.

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Poster Faksimile:

Multimodal 3D-Reconstruction of Dental Anatomy based on CT and DVT

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Introduction:

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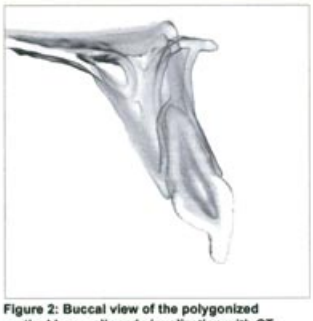

Figure 2: Buccal view of the polygonized cortical bone, clipped visualization with CT data (tooth) superimposed in transparent rendering.

Figure 3: Labial view of the polygonized tooth and cortical bone.

Methods:

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RESULTS:

Fig. 2 and 3 show the polygonized segments of tooth and cortical bone in buccal and labial view respectively.

DISCUSSION:

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[3] Yu Zou et al., Partial volume and aliasing artefacts in helical cone-beam CT, Phys. Med. Biol. 49 2365-2375, 2004