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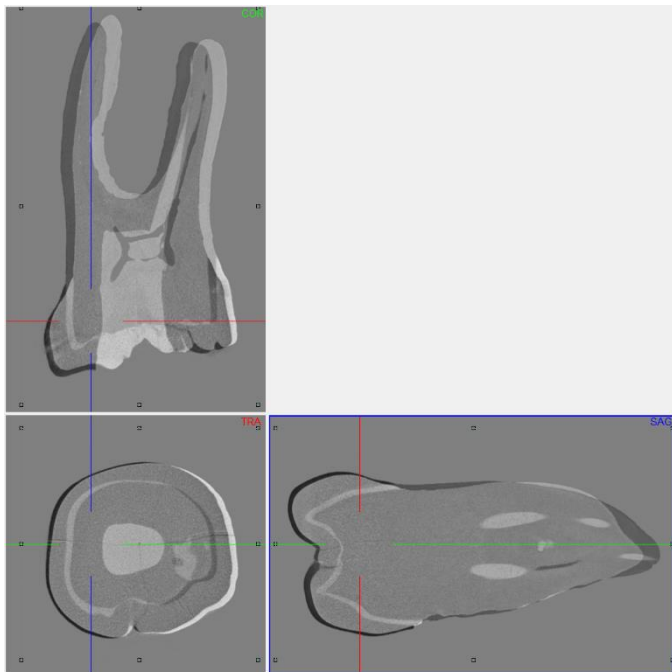
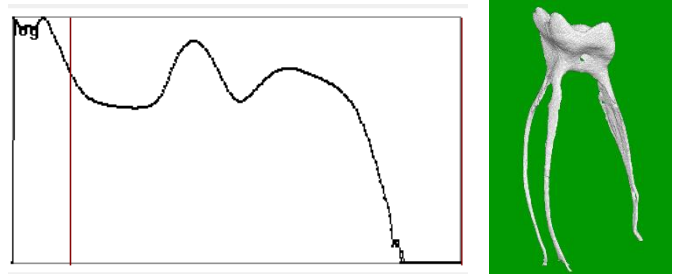
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● **Welcome**

Welcome to the second issue of the Bruker microCT Academy newsletter in 2017! This month our topic is the dentist's chair - specifically, the tooth root canal. MicroCT imaging in endodontic research often involves assessing root canal procedures such as drilling the canals and addition or removal of filler material.

● **3D registration in DataViewer of a molar tooth before and after root canal drilling**

Method notes are already available for general 3D registration in DataViewer. Here the "before and after" molar tooth scans are loaded as reference and target respectively. When registering the tooth scans it can help to move up the lower threshold (green/red lines) on the displayed histogram. This removes surrounding material like plastic tubes or paper tissue from the 3D registration.



● **Save binary images of the root canals in registered reference and target datasets**

In CTAn open the reference dataset in the "Registration" subfolder. Create a binary dataset of the root canals by the following steps: (1) apply inverse binary threshold to

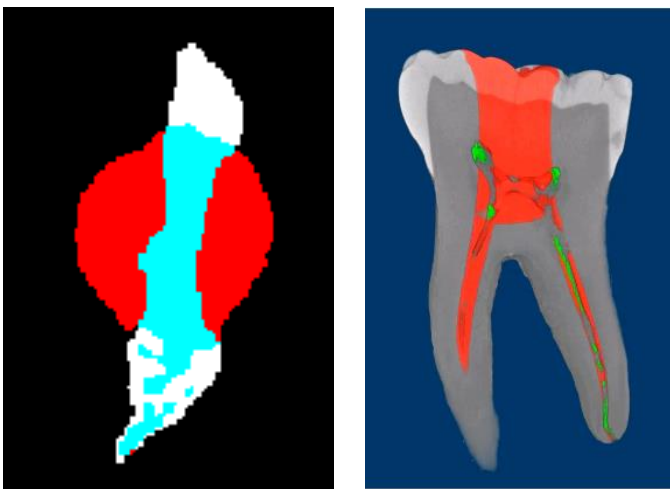
the tooth; (2) in custom processing run despeckle /remove outer objects (2D); 3 – despeckle / sweep (3D) all but largest object; 4 – save bitmaps / image (BMP, monochrome)

● **Analysis 1: Removed (drilled) and added (debris) material**



In CTAn open the binarized root canal dataset from the registered reference ("before") scan. Then load the binarized root canal dataset from the target ("after") scan, either as a BMP ROI, or as a clipboard (note that in CTAn 1.16 you can open a second dataset in the clipboard channel). With these two datasets loaded, we now go to custom processing and do some simple "image arithmetic". Just subtracting one root canal binary from the other, before minus after equals what has been removed – the drilled out dental tissue. And after minus before equals what has been added – in practice this means the drilling debris (Bitwise, the SUB operation). This is an important outcome for endodontists to be able to both visualize and quantify. The image in the next page shows the result of this image arithmetic. The original

image from the before scan – the smaller elongated canal cross-section, is in white. The canal in red is larger after the drilling and circular in cross-section. Blue-shaded white region means space present both before and after. However the pure white areas were space before but solid after, and are debris from the drilling. Both the removed material (before minus after) and the debris (after minus before) can be saved as binarized image datasets using the “save bitmaps” plugin.



- Analysis 2: Touched (eroded by drilling) and untouched root canal surfaces

The analysis of touched and untouched surfaces starts in just the same way as the analysis above of the drilled out and debris material. First the before-and-after scans are registered in 3D. After that, we again make the binary datasets of the root canal spaces in the registered before-and-after datasets. (We can in fact just load the binarized root canal datasets that we already created for analysis 1, above.) Then however we introduce a new step – making binary images of a thin boundary around the root canal only, not the whole root canal volume. We start this with the before, reference dataset, already binarized. First threshold the image dataset in custom processing (necessary even for binary images), then following steps will create a one-pixel thick boundary just one pixel external to the original binary of the root canal:

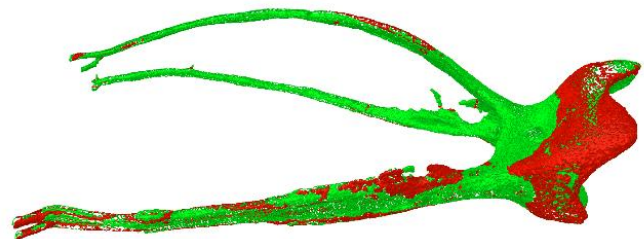
1 – Bitwise / ROI = COPY IMAGE; 2 – Morphological operations / dilate (3D, 1 voxel) applied to ROI; 3 – Bitwise

/ IMAGE = ROI SUB IMAGE; 4 – Save Bitmaps / Image, BMP, monochrome (1-bit).

After this, load into CTAn the binarized dataset (already created from Analysis 2) of the after-scan root canal. Follow a similar procedure but modified to create a 3 pixel thick boundary layer, not just one pixel.

1 – Bitwise / ROI = COPY IMAGE; 2 – Morphological operations / dilate (3D, 2 voxel) applied to ROI; 3 – Morphological operations / erode (3D, 1 voxel) applied to IMAGE; 4 – Bitwise / IMAGE = ROI SUB IMAGE; 5 – Save Bitmaps / Image, BMP, monochrome (1-bit).

The reason for this is to allow for registration error of  $\pm 1$  pixel. The part of the 1-pixel-thick root canal boundary from the before-scan which coincides in space with the 3-pixel-thick root canal boundary from the after-scan, will be considered to be untouched surface, not changed by the experimental procedure. All other surfaces thus will be assigned as touched surface, eroded by the drilling procedure.



In the above image, generated by CTVol as surface rendered models, green means touched surface (eroded by drilling) and red means untouched surface (not changed between scans before and after drilling).

As with the removed and added material (debris) in analysis 1 above, the binary datasets created of the touched and untouched surfaces allow quantitative analysis also in CTAn. Note that in the case of the boundary binary image of untouched surface, since it is 1-pixel thick, it means that the measured volume in voxels cubed also equals the surface area in voxels squared, simplifying the assessment of untouched surface.

These two analyses are described in the “ [MN110 endodontic root canal analysis-debris and untouched surfaces](#)”.

## ● Bruker microCT news

For this year's User Meeting more than 80 abstracts have been submitted from all over the world covering the most diverse microCT applications both in life science as well as in material science.

We are looking forward to welcome you all to another memorable event where we hope you will be able to enjoy the scientific and the social program! Don't forget to submit your picture/movie before May 5<sup>th</sup> and possibly win an iPhone or iPad!

More information on the User Meeting can be found at: <http://bruker-microct.com/company/usersmeeting2017.htm>

## ● Upcoming events

Bruker microCT will participate with an exhibit in the forthcoming conferences. Please click the link below for more information. We hope to see you there!

- [AACR](#) Apr. 01 – 05 Washington DC, USA
- [EMIM](#) Apr. 05 – 07 Cologne, Germany
- [Interpore](#) May 08 – 11 Rotterdam, The Netherlands
- [ECTS](#) May 13 – 16 Salzburg, Austria
- [ATS](#) May 19 – 24 Washington DC, USA
- [BRS](#) Jun. 25 – 27 Bristol, UK
- [ICTMS](#) Jun. 26 – 30 Lund, Sweden
- [URTEC](#) Jul. 24 – 26 Austin, USA

## ● Image of the month

A part of an olive tree scanned in the SkyScan1173. This desktop scanner can accommodate large and irregular objects.

