Application Note # AP0121 May 2012

Application Protocol for Small Animal Lung Volume Segmentation Employing the Albira CT and PMOD Software

Connor Wathen,[1] Todd A. Sasser,[2] Sarah E. Chapman,[1] W. Matthew Leevy[1]

Author Information: *1-University of Notre Dame, Notre Dame, IN; 2-Bruker BioSpin, Billerica, MA*

Introduction

This application protocol provides instructions for segmenting the lung volume in small animal Albira µCT datasets to allow for quantitative volumetric measurement, and unique visualization of the lung volume merged with the original whole CT. Masking for heart and kidney regions for visualization of merged original whole CT, lung volume, heart region, and kidney regions is also shown. This method may be applied to Albira µCT small animal disease model datasets to assess lung volumes.

Protocol

Animal

In the example shown an adult male mouse (various breeds have been evaluated using this technique) was employed for the in vivo imaging described here. Mice may be anesthetized by Isofluorane (2.5% flow rate) and kept under at 2.5% via a nose-cone setup for imaging.

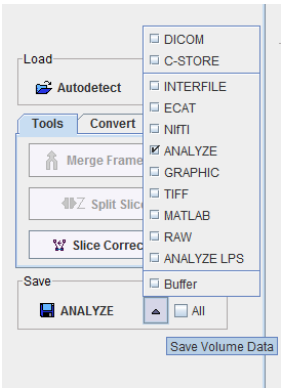
Visipaque™ (GE Healthcare) may be administered via IV tail vein injection at 100µL directly prior to CT imaging for contrast for kidney structure.

µCT Acquisition and Reconstruction

Acquire images using the Albira CT system. The Albira CT system is factory calibrated to Hounsfield units (HU). This protocol has been successfully employed using both Good and Best Albira CT settings. In the example data set shown here, Best CT (600 projections) at 65 mm FOV, 45 kVp, and 400 µA was used. Once the acquisition is complete, perform a filtered back-projection reconstruction using the Albira Reconstruction module.

Masking and Segmenting

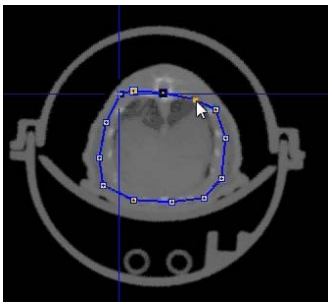
Masking and Segmenting for Lung/Airway Volume
Masking and segmentation may be performed using the PMOD software (PMOD technologies, Zurich, Switzerland). The PMOD software is a modular PET analysis software that is provided standard with the Albira system. For the purposes of this application, Masking is employed to remove elements outside a defined HU range. This is applied to facilitate subsequent segmentation for lung volume or simply to isolate the heart and kidney regions for visualization purposes. The thoracic cavity is initially masked to isolate a valid region for lung Segmentation. Segmentation of the lungs is based on the HU units of the lungs. The volume for the lung region can be derived from the segmentation process.

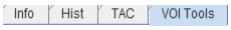


To begin open the µCT .hdr file in the PMOD PBAS module. Save the file in the Analyze file format (see figure to right). (Depending on the size of the file and the workstation being used it may be necessary to reduce the file. To do this select the tools tab at far right and select the Reduce tab Reduce. Set X, Y, and Z to 2, check the Replace check box and select the Run button Run).

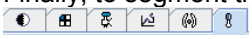
Next, create a Volume of Interest (VOI) generally surrounding the thoracic cavity and airways. (If lung segmentation without airways is desired create a VOI around the lung region only). Navigate to the VOI tab 

at second from the left in the toolbar. Select the Add/Edit vertex button  . Begin drawing successive Regions of Interest (ROIs) though the Z-plane to create a VOI around the thoracic region. The "Copy actual ROI, move to the next slice and paste ROI from buffer" tool  may be employed as long as the ROI position and size remain relevant. The figure at right shows an example of an appropriate ROI in the Z-plane.



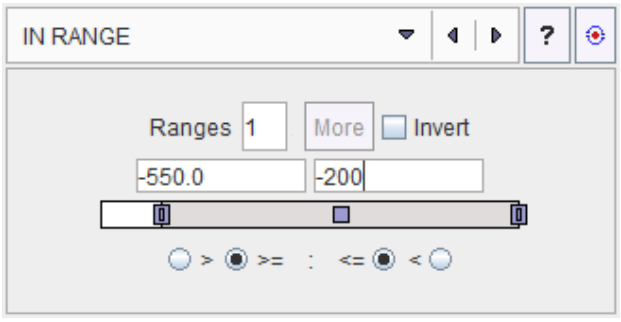
Once the thoracic region is encompassed select the VOI Tools tab 

at far right and select the "Mask voxels outside the selected VOIs"  button. A dialogue box will appear. Enter -1000 corresponding to the HU unit for air. Leave the "Create new study" check box selected and select Yes. After processing the elements outside the VOI should no longer be visible (see figure to right).

Finally, to segment the lung volume select the tools tab  at the far right and select the External tab 

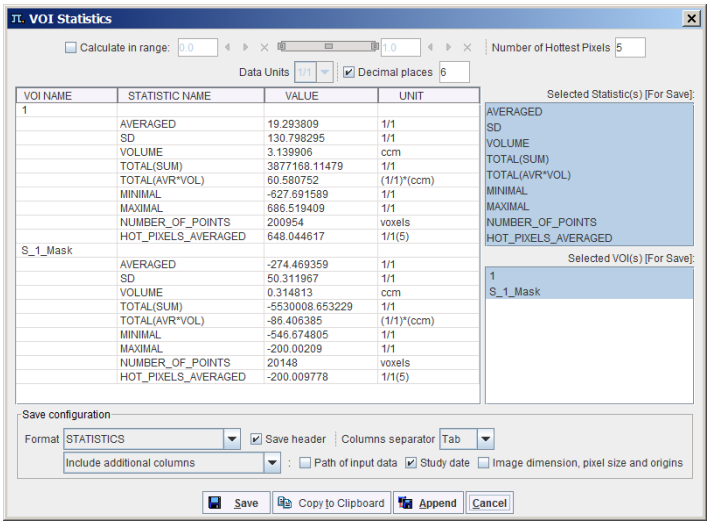
. In the available pull-down menu select Segmentation 

. Select IN RANGE from the pull-down menu and enter the range -555 to -200 in the dialogue provided (see figure below). Select the Additional results check box and the Create VOI Template/Mask and View statistics check box. Select OK. The lung/airway volume is now segmented and a VOI Statistics report will appear (see figure below). The lung volume in this example is 0.314 ccm which is within a typical range for a healthy adult mouse.



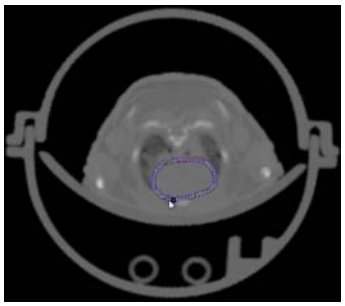
Save a unique version of the file in the Analyze file format to be used further below for Merging volumes.

A screen recording for the process described here for Masking and Segmenting for lung/airway volume can be viewed here: http://youtu.be/GcGt3kj8N6g (change the image quality to 1080p for best viewing). If you do not wish to perform Masking for the heart and/or kidneys skip to the section Merging Volumes and Creating a Movie to create a unique view for the lung volume merged with the whole CT.



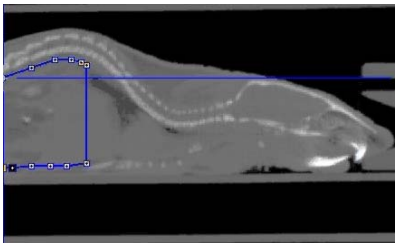
Masking for the Heart Region

Open the original saved Analyze file CT dataset. Reduce the image if required as described above. Create a VOI around the heart region using the Add/Edit vertex tool or the Draw vertices  tool (see figure to right). Once the VOI is complete perform Masking as described above. The elements outside the VOI should no longer be visible. Save a unique version of the file in the Analyze file format to be used further below for Merging volumes. A screen recording for the process described here for Masking for the heart region can be viewed here: http://youtu.be/ne7j9j7Tpi4.



Masking for the Kidney Regions

Open the original saved Analyze file CT dataset. Reduce the image if required as described above. Create a VOI around the general abdomen area where the kidneys are located using the Add/Edit vertex tool or the Draw vertices tool (see figure to left). Once the VOI is complete perform Masking as described above. The elements outside the VOI should no longer be visible. Save a unique version of the file in the Analyze file format to be used further below for Merging volumes. A screen recording for the process described here for Masking for the heart region can be viewed here: http://youtu.be/30TvAZ6csec.



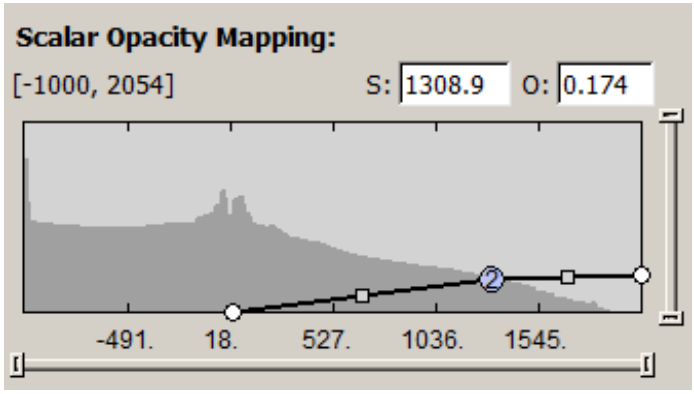
Merging Volumes and Creating a Movie

VolView (Kitware, Clifton Park, NY) will be used to merge the volumes from the unique Analyze format files saved above. First, open the original saved Analyze file CT data set, or select the file from the Open Recent Files if the file has recently been opened. When the option box appears select Next for all options and Select Finish.

Next, select the Plugins tab at third from the right. Select Utility>Merge Volumes from the Plugin pull-down menu. Uncheck the "Rescale components" checkbox. Select the Assign Second Input button. An Open File menu will appear. It may be necessary to set the file format in the Open File pull-down menu to DICOM to select files. Select one of the unique Analyze format files for the lung/airway segmentation, heart region, or kidney region by navigating to the file path and selecting the file. Finally select Apply Plugin. When the option box appears, select Next for all options and select Finish. Each unique Analyze format file may be added to the Merge in turn by selecting the Apply Plugin button and repeating the procedure.

To begin optimizing the display for the Merge select the Color/Opacities tab at far left. Double-click on the Color/Opacity Preset "Ramp to 20%, Black to White". Double-click the top left image panel to maximize the view. To adjust the display for the whole CT select "1" in the Component pull-down menu.

Adjust the display for the Color/Opacity Settings by adjusting the position of the black line drawn through the histogram. Double-click on the black line to create new points for adjustment. The figure below shows an example Scalar Opacity Mapping setting for a typical Albira µCT small animal dataset without Segmentation or Masking.



Change the Component value from the available pull-down menu and adjust the Scalar Opacity Mapping for each component (i.e. lungs, heart, and kidneys). The Scalar Color Mapping control may be used to adjust the scale and color of the elements. The volumes displayed may be rotated by left mouse depressing and dragging over the image. The image to the left shows the display for the Whole CT/Lung Merged volumes following optimization of display parameters.

To generate a rotation movie of the display navigate to the review tab at center. Be sure to adjust the display so that the animal axis is straight. In the Movie control menu, set the desired number of frames (e.g. 72), the X starting position to 0, and the X rotation to 360. Select Create. Enter a file name and type. Select Microsoft Video 1 when prompted. Once processing is complete, the video will be available in an .avi format and may be embedded in presentations. A screen recording for the process described here for merging volumes and creating a movie can be viewed here: http://youtu.be/PObV49ml0Po. An example of a rotation movie of this dataset can be viewed here: http://youtu.be/tUmdTU728BE.

For more information, contact your
Bruker BioSpin dealer, or contact us directly at:

Telephone:
Call 1-978-667-9580 and select Option 4.
Mon. through Fri., 8:00 a.m. – 6:00 p.m. EST
E-mail:
molecularsupport@bruker.com
Web:
http://www.bruker.com

The information contained in this document is subject to change without notice. Bruker BioSpin makes no warranty of any kind with regard to this written material. Bruker BioSpin assumes no responsibility for any errors that may appear in this document.