Appendix B Micro-CT Image Processing and Visualization

The formats of the CT images from the CT scanners usually are a series of 2D cross-sections or a 3D array storing the volumetric data. In order to calculate the geometry and topology of the pore space and to simulate the physical properties, it is necessary to view CT images and then to choose an area or a space of CT images to do the simulation. These tasks can be solved by the free software ImageJ (http://imagej.nih.gov/ij/) which is a public domain, Java-based image processing program developed at the National Institutes of Health. It has open architecture that provides extensibility via Java plugins and recordable macros.

B.1 Importing and Saving Images

The format of one file is a 3D array including the grey scale of the whole image can be imported by "File->Import->Raw" and input the image type and the size of the images in three directions in this dialogue box.

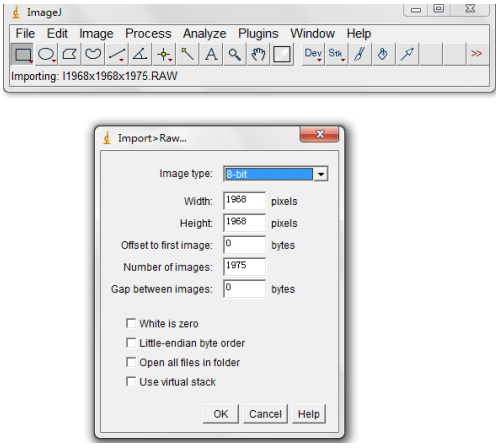

Figure B.1: Dialogue box for importing 3D volumetric data.

A series of the 2D cross –section can be filed by "File->Import->Image Sequence".

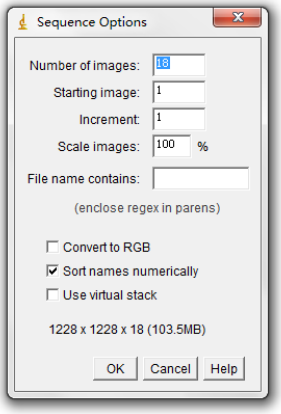

Figure B.2: Dialogue box for importing a series of 2D cross section images.

To save the images, go to "File->Save as->Raw Data". In order to keep the images saved in the same format, the size of each point in the images should be set in "I/O Options" dialogue in "Edit->Options->Input/Output".

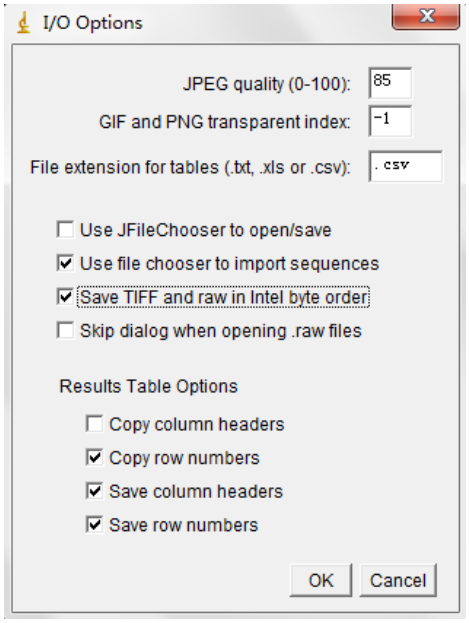

Figure B.3: Dialogue box for saving images in the same format.

B.2 Processing Images

B.2.1 Cropping

A sub samples can be extracted from the original images by choosing a cropping area by mouse and the order "Image->Crop" can be used to get the sub sample.

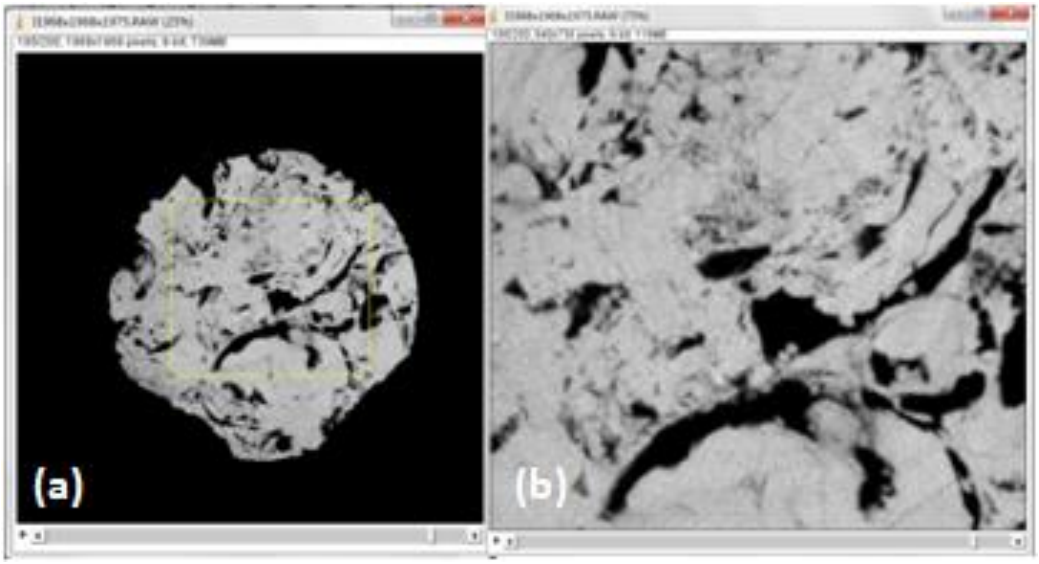

Figure B.4: The cropping area is set by the square with yellow boundary in (a) and (b) is the result after cropping.

B.2.2 Filtering

A median filter can be implemented by "Process->Filters->Median" showing the dialogue to set the radius of the region where the average of these grey scale data is used to replace the grey scale data of the point centred in this region. This median filter is 2D.

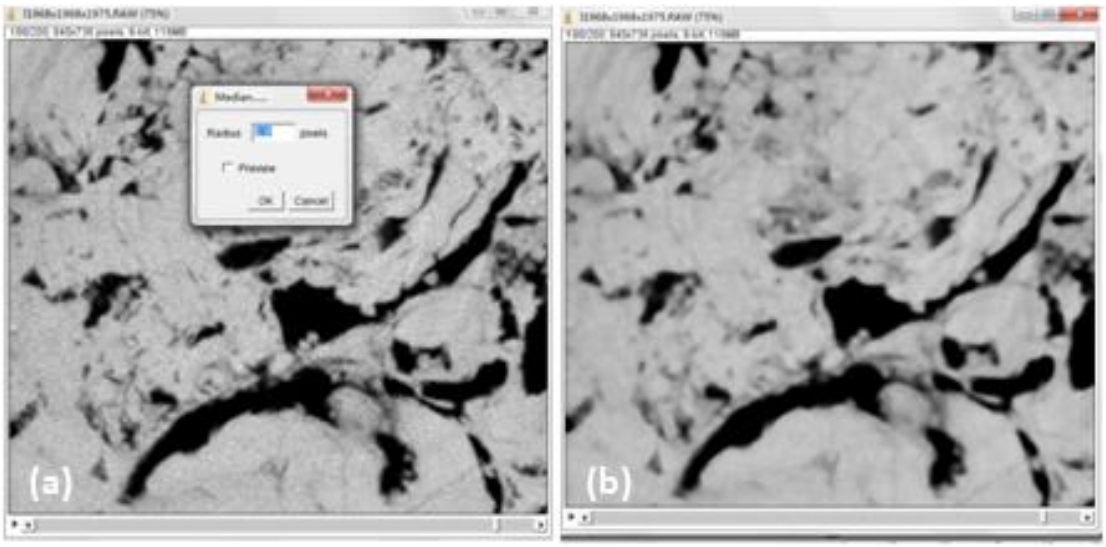

Figure B.5: The cropped images can be filtered by the median filter just set the radius of the filter. The effect of median filter can be shown in this figure. The noise which is the small points in (a) can be smoothed in (b).

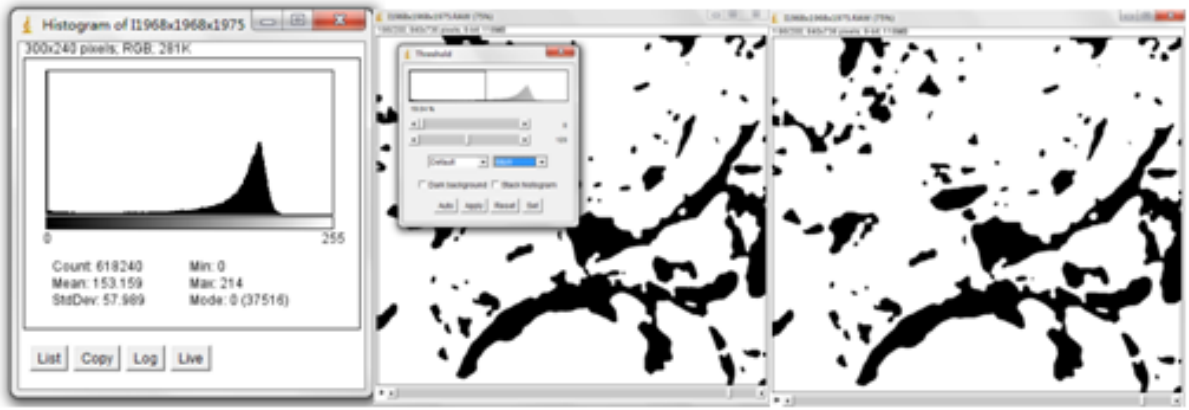

Figure B.6: The histogram of the images which can be used to offer threshold. If the threshold is difficult to extract from the histogram, the threshold can be chosen by comparing the difference of segmentation results with variable thresholds by the "Threshold" dialogue in (a) and (b). (c) is the binary image from auto threshold by the "Auto" function.

B.2.3 Segmentation

The segmentation is to divide the above grey scale data into binary data by setting threshold value.

This value can be determined from the histogram of these images shown from "Analyse->Histogram" in Figure B.6. There are two peaks in this histogram, the grey scale data of the one peak is in 0 and the grey scale data for the other one is about 191. The threshold data should be determined in the flat transition between the two peaks. Due to flat of the valley, it is not easy for user to determine the threshold while a auto threshold can be used in this software "Image->Adjust->Threshold". Visual inspection can be implemented by the dialogue box from this order to show the results of segmentation with different threshold by moving the tags in this box. The segmentation by auto threshold can be implemented by the "Auto" in this threshold dialogue box.