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**Hele Shaw Model Instructions**

**Introduction**

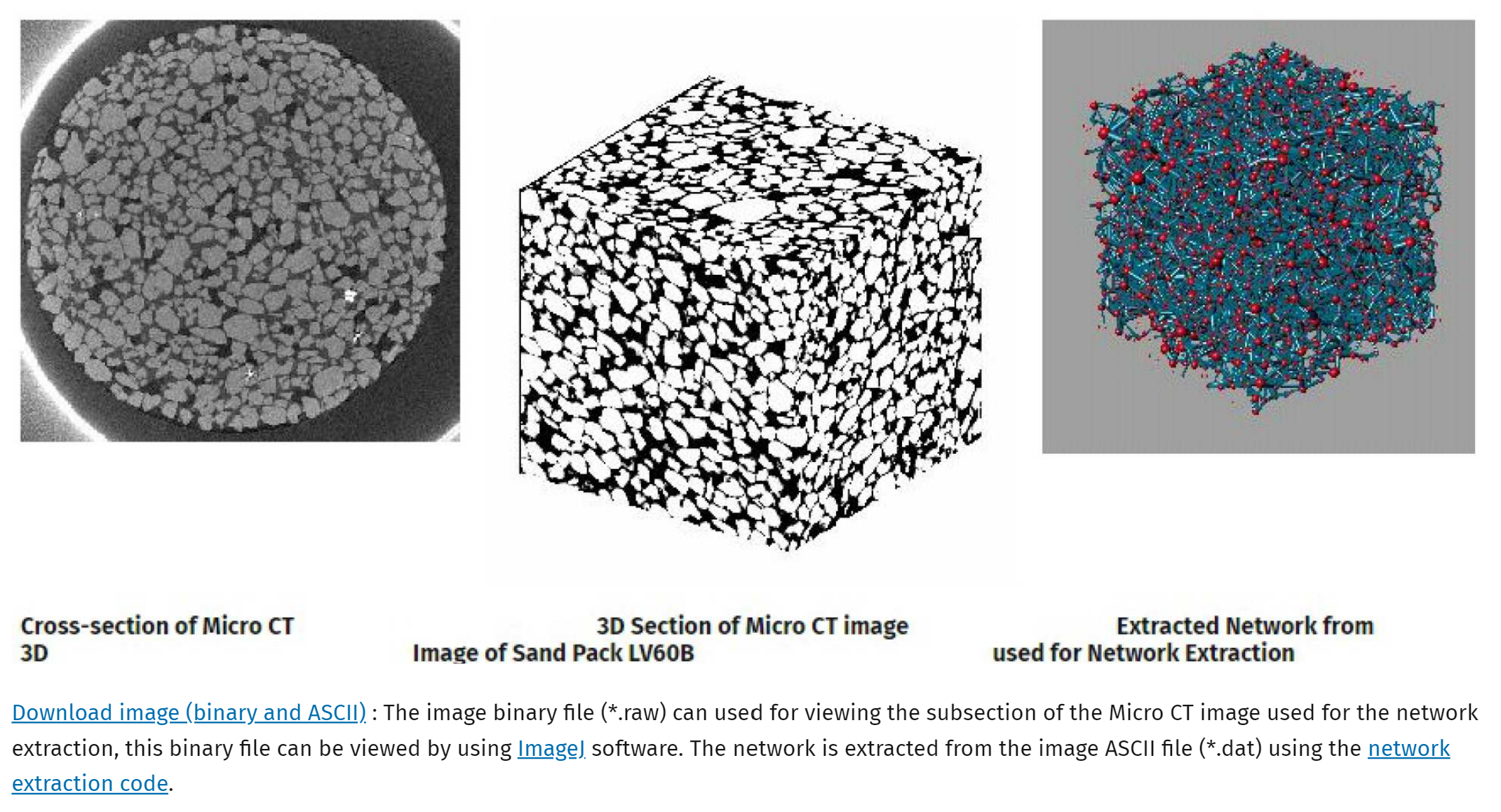
This step-by-step guide shows how to create a 3D model of a Hele-Shaw porous media cell that allows two-dimensional fluid flow. The source images are from Imperial London College. Python will be used to extract the network from these images and Fusion 360 will convert the network to a printable 3D model.

**Materials**

* Windows PowerShell
* Python 3
* Inkscape
* Autodesk Fusion 360

**I. Retrieve Python Codes and MicroCT image**

1. Create a new folder which will now be referred to as the WorkFolder. Take note of the folder’s exact location. For this guide, the location is *C:\Users\user\Desktop\WorkFolder*
2. Go to <https://github.com/Azshian/Hele-Shaw-Model> and download these files to the WorkFolder.
   1. HeleCode.py
   2. HeleBorderApparatus.stl (not uploaded yet)
   3. Folder - HeleViewingApparatus (not uploaded yet)
   4. ImageProcess.py (not uploaded yet)
3. Go to <https://www.imperial.ac.uk/earth-science/research/research-groups/perm/research/pore-scale-modelling/micro-ct-images-and-networks/>
4. View the different image scans by clicking on the network name. This guide will select **Sand Pack (LV60B)**.
5. Click [**Download image (binary and ASCII)**](http://www3.imperial.ac.uk/pls/portallive/docs/1/46729696.ZIP)which will give a compressed zip file.
6. Extract the zip file and move the .dat file into the WorkFolder. The .raw file is unused.



**Figure 1. Screenshot from website from ICT**

**II. Select slice from Pore Network**

1. Open Windows PowerShell and change the directory to the WorkFolder by typing:

*cd “C:\Users\user\Desktop\WorkFolder”*

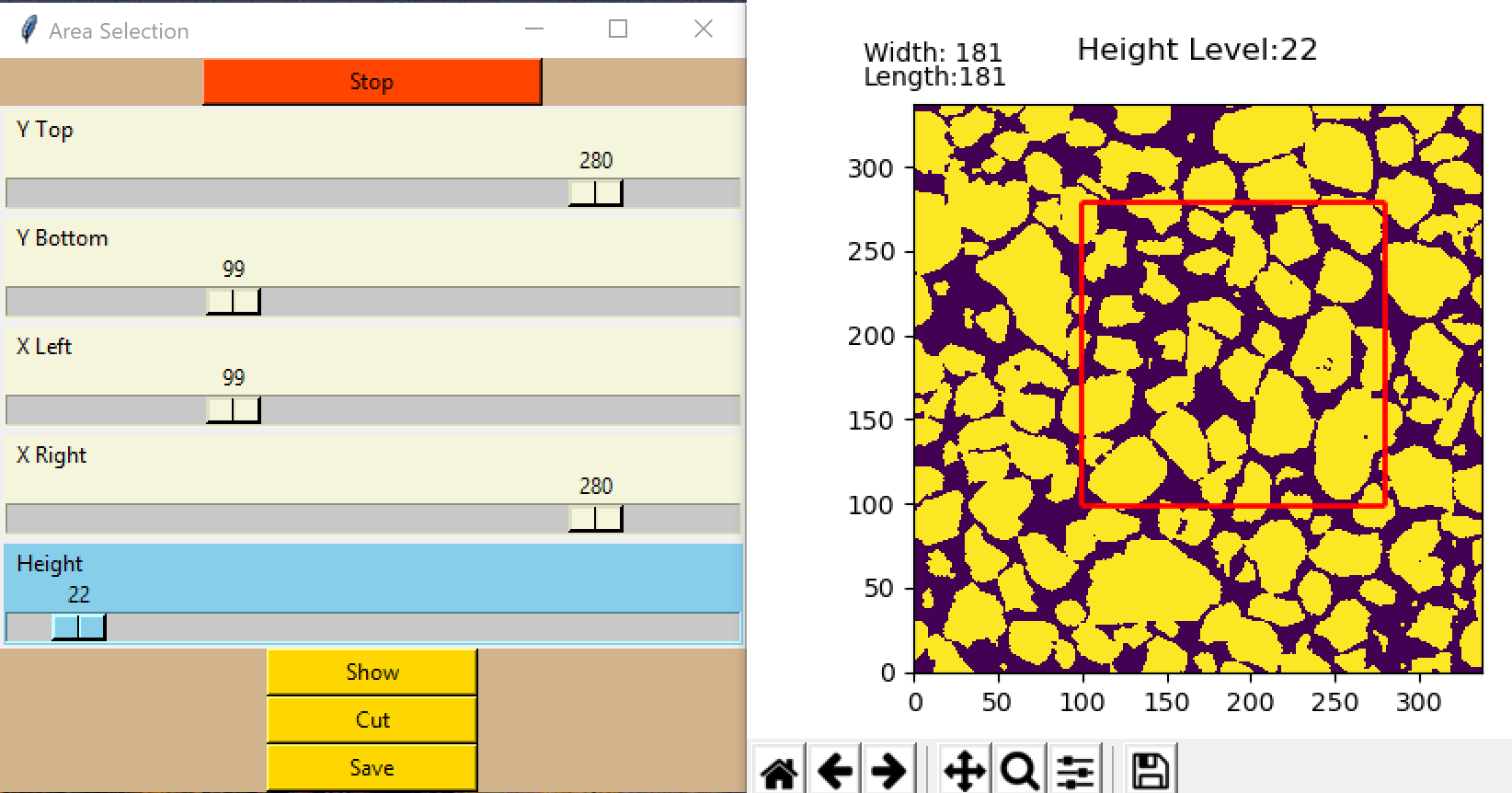
\*use your specific directory for this step\*

1. Load the Python code and the image file by typing:

*python HeleCode.py LV60*\_*02.dat*

\*if different network was used, use that name instead\*

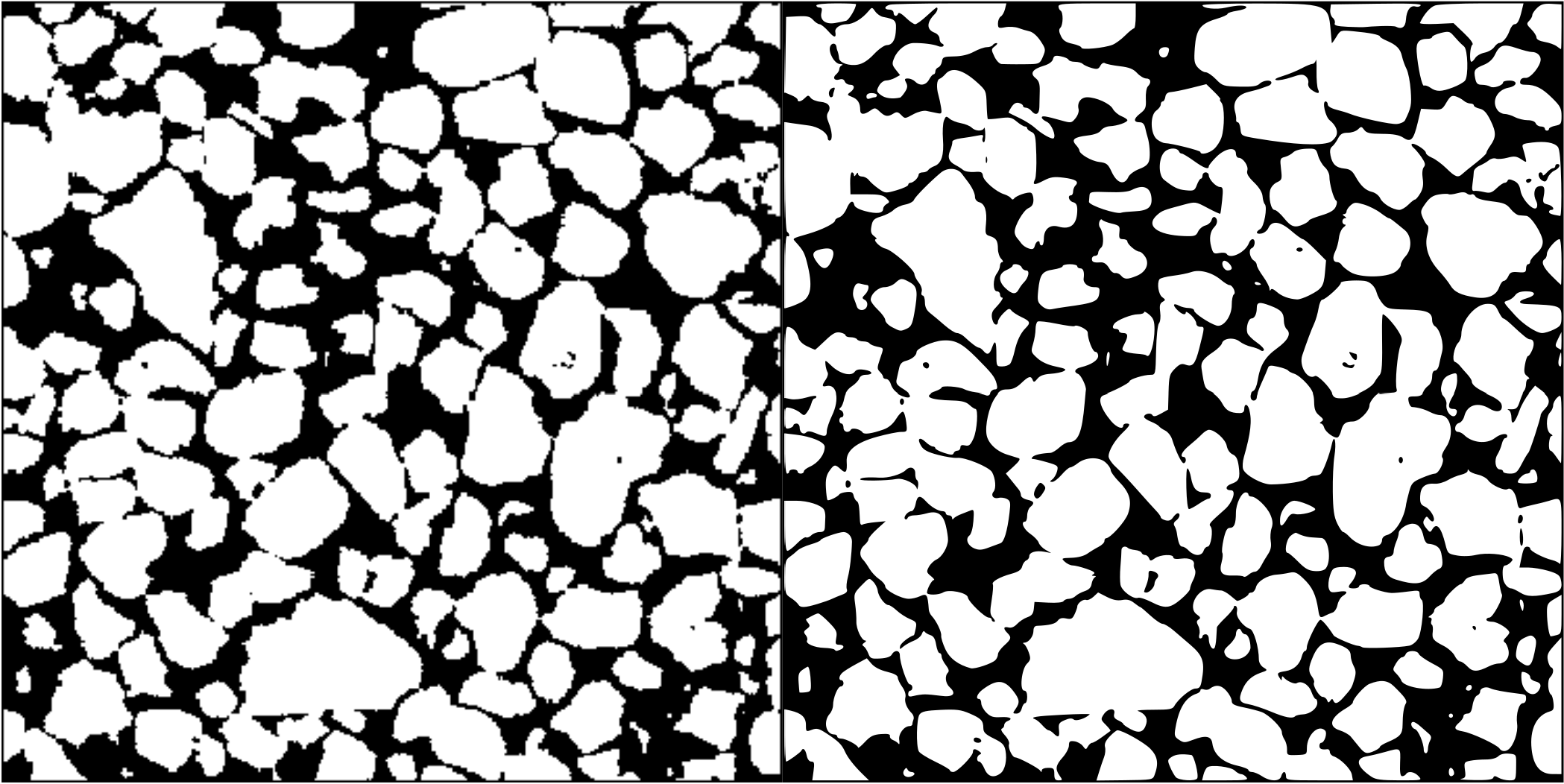
1. The **Area Selection** GUI will appear, with four sliders and four buttons. Click **Show** to open the image.
   1. The pore network is shown in another window. The filled spaces are yellow and the void spaces are purple.
   2. The red border surrounding the network indicates the area selection.
2. Select the desired network
   1. Use the GUI slider **Y Top, Y Bottom, X Left,** and **X Right** to change the area selection. Make no changes if the full area of the network is desired.
   2. Use the **Height** slider to select the height level of the network.
   3. When any slider values are changed, press the **Show** button to update the image.
   4. The desired network must square in shape for the model to fit in the apparatus. Make sure the width and length are equal.
3. Press the **Cut** button to view the selected area.
   1. If more changes are desired, simply press the **Show** button again to view the full network with the red borders.
4. Once the desired area is found, press **Cut**, then press **Save.** The pore network will automatically be saved to the WorkFolder as a black and white image called NetworkSlice.png



**Figure 2. Slider GUI (left) controlling the Network Image (right)**

**III. Convert PNG to SVG**

1. Open Inkscape. Drag NetworkSlice.png into workspace. A pop-up menu will appear. Use the following options:
   1. Import Image Type: Embed
   2. Image DPI: From File
   3. Image Rendering Mode: None
2. Click on the image. Then, on the ribbon, under **Path**, select **Trace Bitmap**. Press OK and close the window.
3. A copy of the image will be produced in a vector format. The smooth vector image is generated right on top of the original pixel image. Drag the vector image out of the way to view the original image and delete the pixel image.
4. Go to **File** and select **Save as** to save the file as an SVG called NetworkSlice.svg



**Figure 3. Original Pixelated Image (left) vs New Vector Image (right)**

**IV. Create Hele-Shaw Cell This might be ridiculously complicated. Do the best you can**

1. Open Fusion 360
2. At the top right corner of the ribbon, click on your account name, and click **Preferences**
   1. Under General, and under Design, ensure that **Allow 3D sketching of lines and splines** and **Auto project edges on reference** are activated.
   2. Click Apply and OK.
3. On the ribbon, under **Solid** go to **Insert** and select **Insert SVG**. Three orange planes appear at the origin.
   1. Select the x-y plane (the plane below the other two).
   2. Import VectorSlice.svg
   3. Press OK. Press **Finish Sketch.** The network image is now on a sketch called Sketch1.
4. Use the view cube on the upper right corner to rotate the camera around the model. On the bottom, there is a small ribbon with pan and zoom features.
5. View the bottom of Sketch1.
6. Create a new sketch, automatically called Sketch2 and make a square exactly on top of the perimeter Sketch1.
   1. The cursor should snap to the corner points of Sketch 1.
   2. Click **Create Sketch**.
7. Extrude this sketch by pressing the keyboard button “e” and clicking on Sketch2. Extrude this an arbitrary amount of negative 1 mm. This will act as the base of the Hele-Shaw cell.

**Figure 3. Model with the Square Base below the Image Sketch**

1. All of the pore network’s void spaces located on Sketch1 will now be cut into the base.
2. Select Sketch 1 from the drop down menu located on the left.
3. Left click on all areas that need to be cut into the base.
4. Scale the model to make dimensions this:
5. Base needs to be 2 mm tall. The Pore network needs to be 1 mm tall. The final model size is 100 mm x 100 mm x 3 mm.
6. Save workspace and save stl file.

**Figure 4. Completed Hele-Shaw Cell**

**V. Attach Hele-Shaw Cell to Hele-Shaw Apparatus**

Needs to be completely rewritten

**VI. 3D Print Hele-Shaw Apparatus**

Print

**VII. 3D Print Video Apparatus (Optional)**

Download STL files.

3D Print

Needs to be completely rewritten

**VIII. Build Apparatus**

Needs to be completely rewritten