AI-Assisted Image Segmentation and 3D Analysis

Ronell Sicat
KAUST Visualization Core Lab (KVL)

training webpage:
wiki.vis.kaust.edu.sa/training/scivis/2023/avizoilastik

This workshop is being recorded.

KVL provides **expert support and collaboration** in **data visualization** and **data science**

- Scientific visualization
- Large data analysis
- Distributed visualization

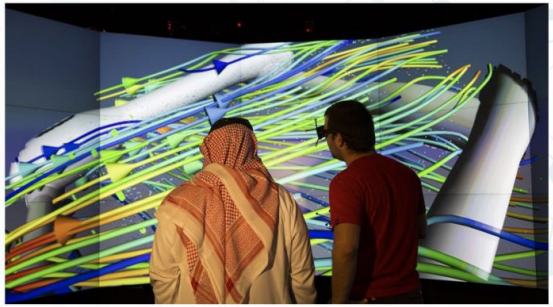
- Information visualization
- Visual analytics
- Statistical Analysis

- *Image segmentation*
- *3D data analysis*
- Virtual reality

- Data science
- Machine learning
- Deep learning

KVL offers state-of-the-art **visualization facilities**

ZONE 1/2 DISPLAY WALLS: 2D/3D Analytics



CUBES VR

ZONE 5 VR

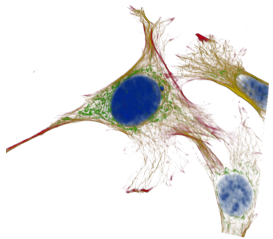
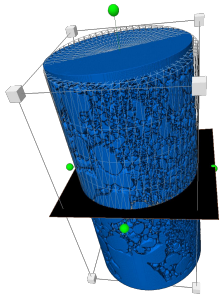
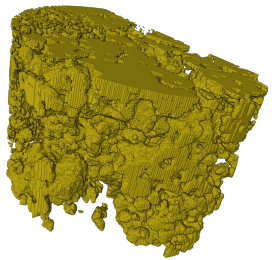
AR/VR HMDs

wiki.vis.kaust.edu.sa

help@vis.kaust.edu.sa

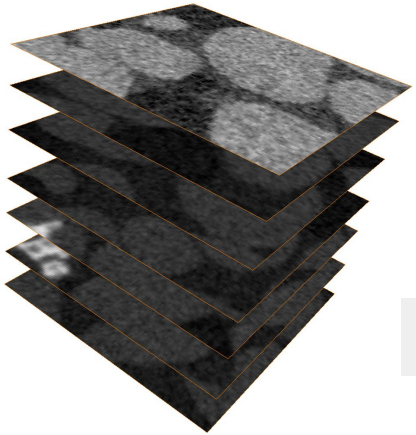
Schedule

- 15 mins: Workflow Overview
- 30 mins: Basic Segmentation using Avizo
- 30 mins: AI-Assisted Segmentation using Avizo
- 15 mins: **Break**
- 30 mins: AI-Assisted Segmentation using Ilastik
- 30 mins: Common Analysis Workflows

Workflow overview

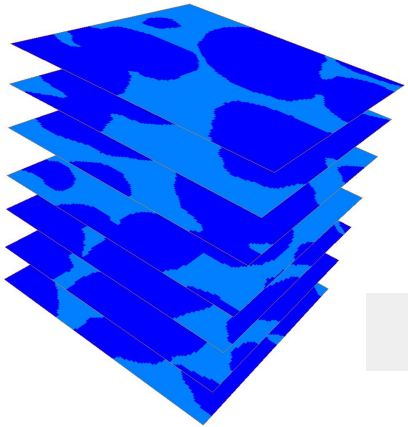
image stack



e.g., 16-bit images
(tiff, png, jpeg)

segmentation

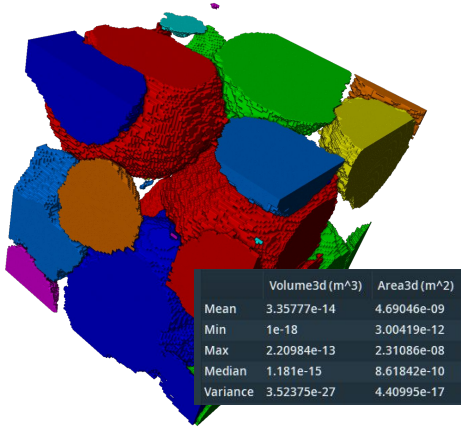
label images



e.g., 8-bit images
(tiff, png)

analysis

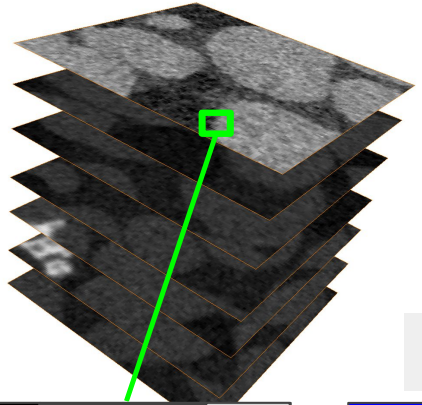
analysis results



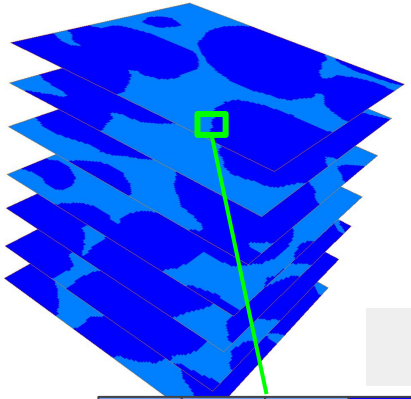
e.g., tabular data
(csv, excel)

Important concepts

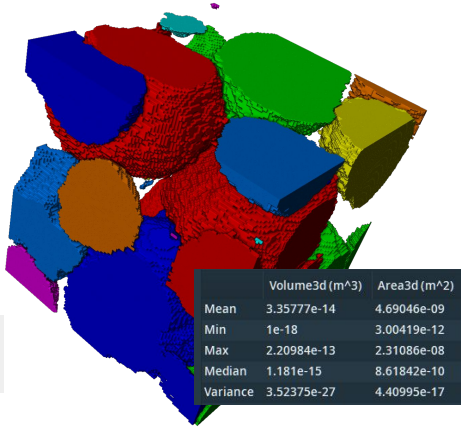
image stack



label images

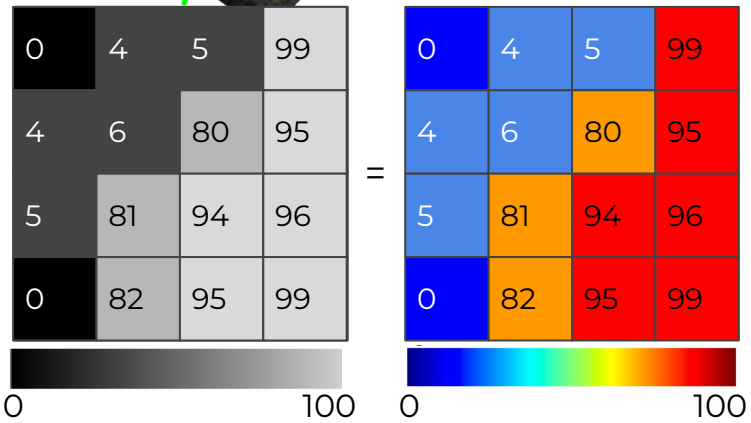


analysis results



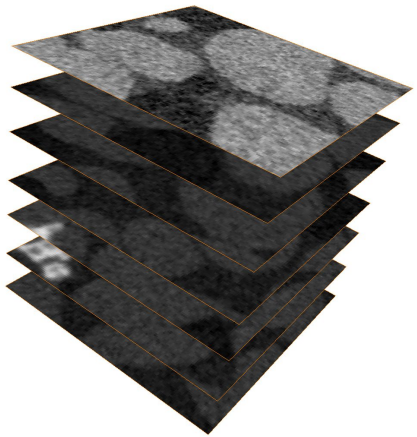
segmentation

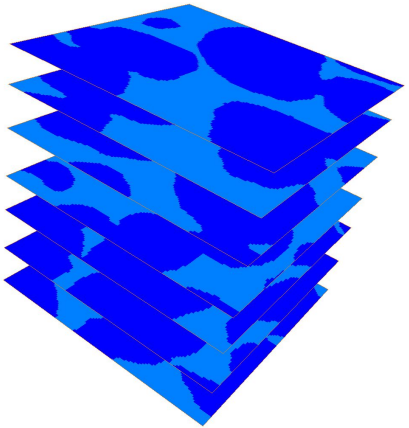
analysis

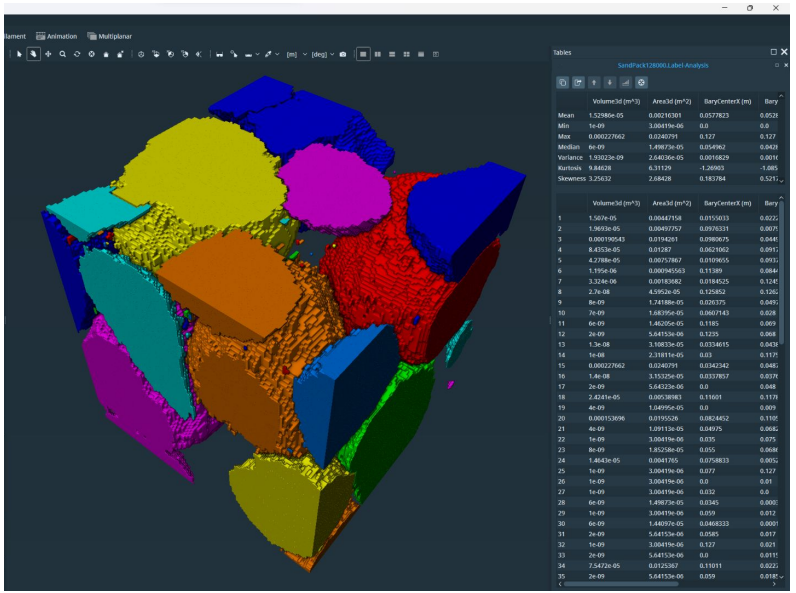


	air	sand
count	7	9
fraction	0.44	0.56

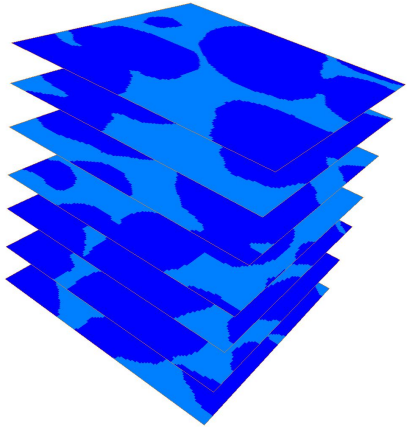
Preview: Avizo sand sample

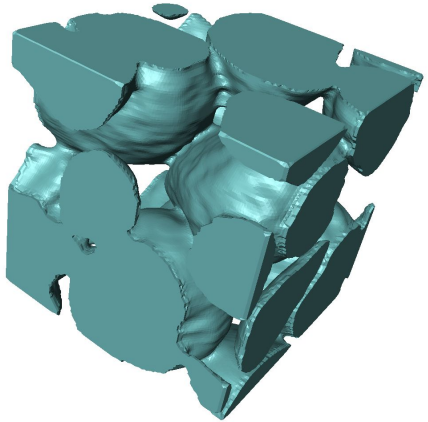






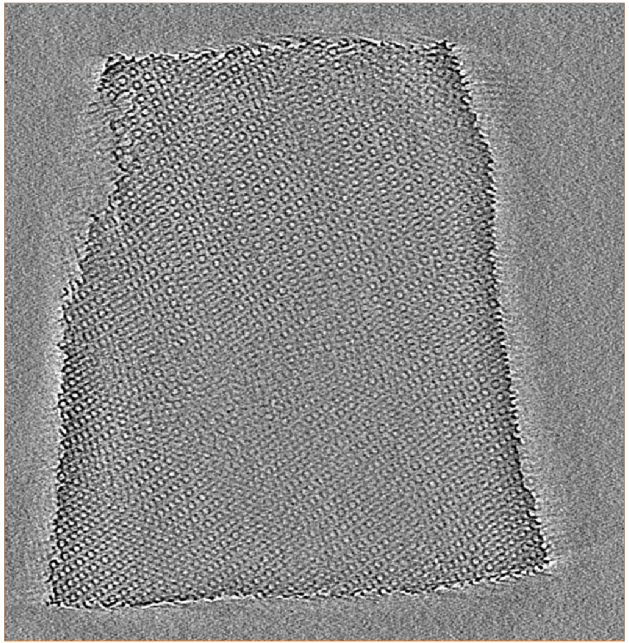
Preview: Avizo sand sample

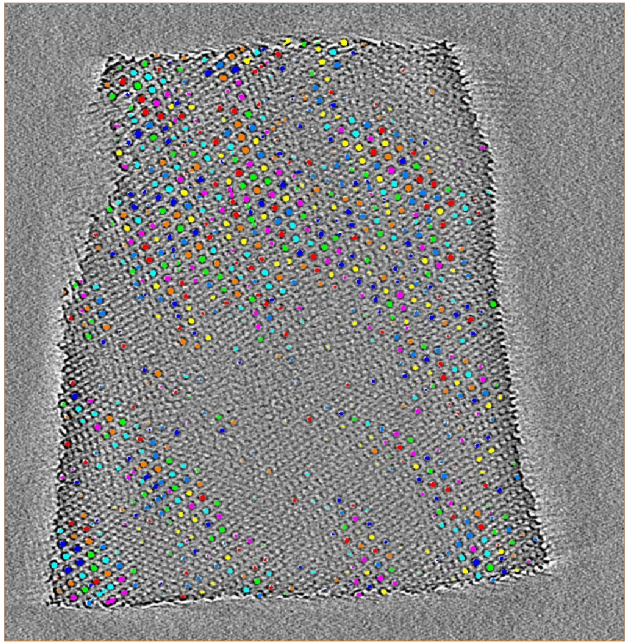


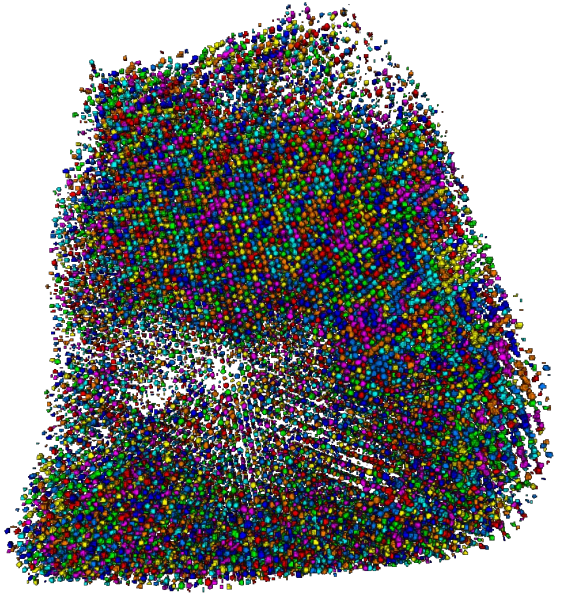


KVL YouTube Channel:
https://www.youtube.com/@kaustvislab

Preview: Electron Tomography of Zeolite







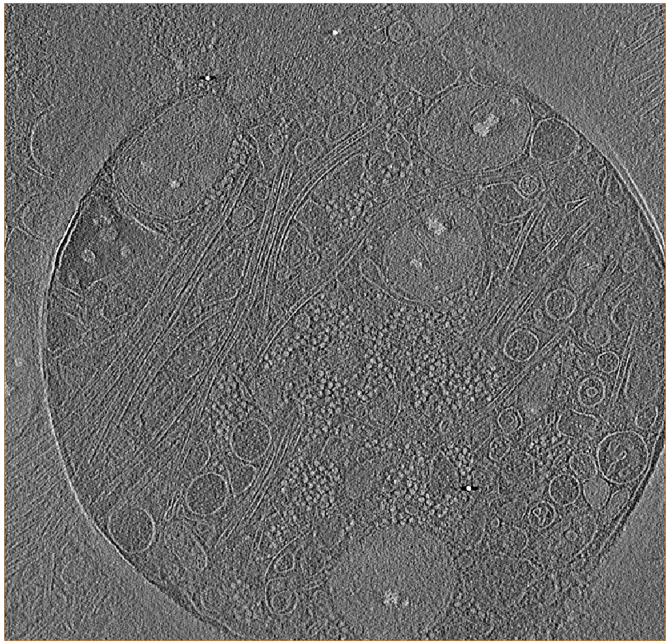
data c/o Georgian Melinte @IAC Core Lab
([Parsapur et. al, 2023])

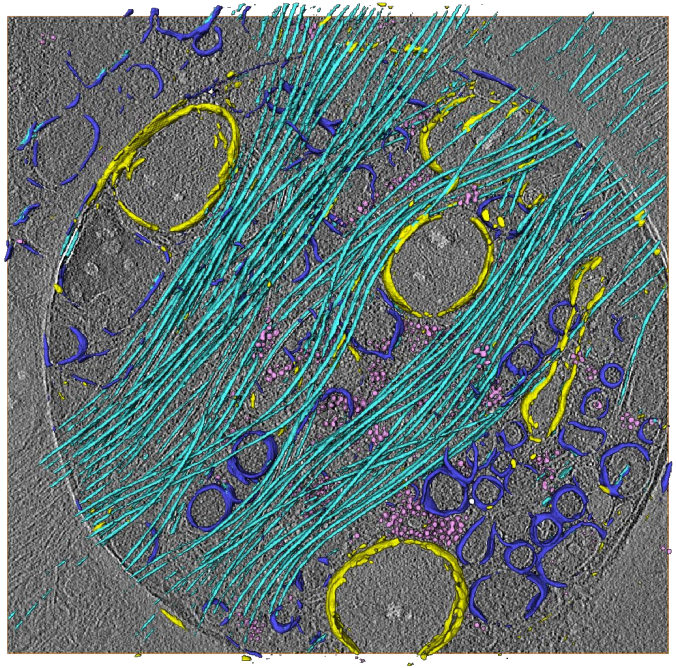
Post-Synthetic Ensembling Design of Hierarchically Ordered FAU-type Zeolite Frameworks for Vacuum Gas Oil Hydrocracking

Rajesh Kumar Parsapur, Amol M. Hengne, Georgian Melinte, Omer Refa Koseoglu, Robert Peter Hodgkins, Anissa Bendjeriou-Sedjerari, Zhiping Lai*, Kuo-Wei Huang**

Angewandte Chemie

Preview: Cryo-Electron Microscopy of a Cell





data from Avizo xtras
https://xtras.amira-avizo.com/xtras/ai-assisted-tool-for-cryoem-segmentation

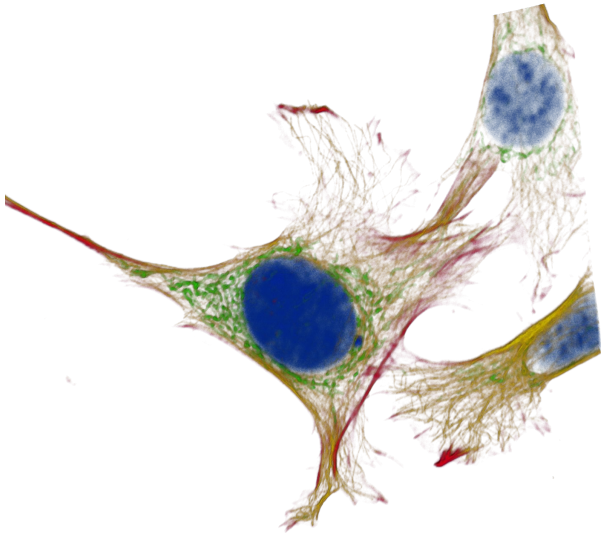
[1] Muyuan Chen, Wei Dai, Stella Y Sun, Darius Jonasch, Cynthia Y He, Michael F Schmid, Wah Chiu & Steven J Ludtke, Convolutional neural networks for automated annotation of cellular cryo-electron tomograms, Nature Methods 14; 983-985, 2017.

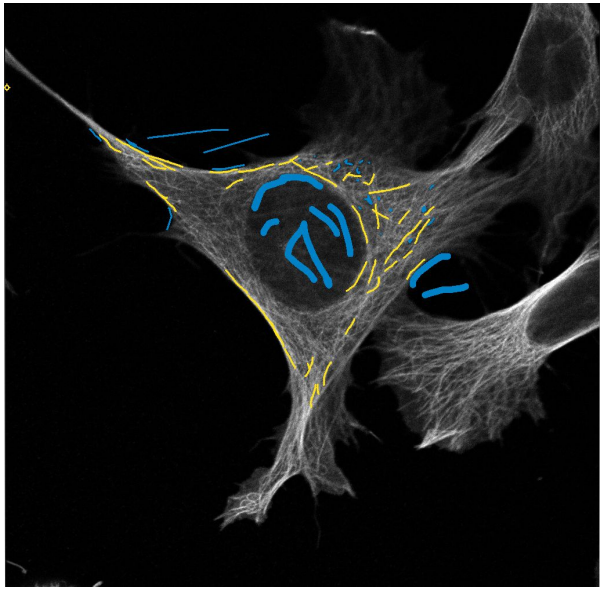
Preview: Electron Microscopy of a Cell

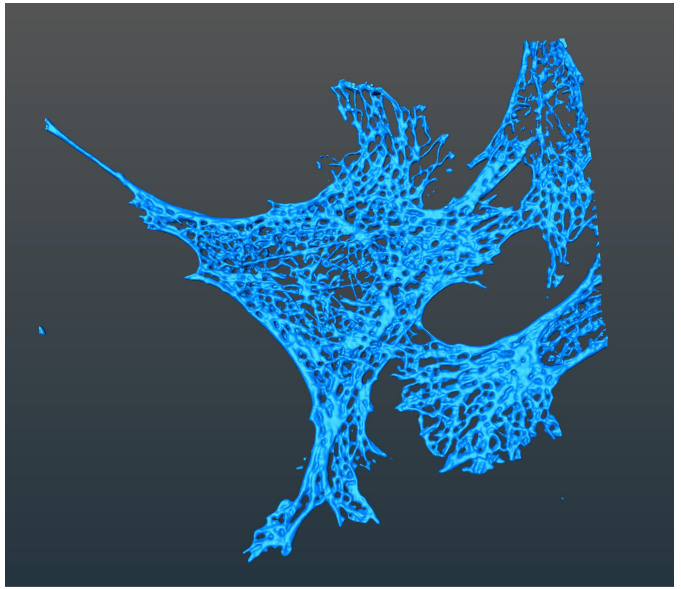
data from Bioimage.IO
https://bioimage.io/#/?partner=ilastik&id=10.5281%2Fzenodo.6406803

Constantin Pape, & FynnBe. (2021). constantinpape/torch-em: For zenodo (0.1.0post1). Zenodo. https://doi.org/10.5281/zenodo.5108853

Preview: Confocal Microscopy of a Cell

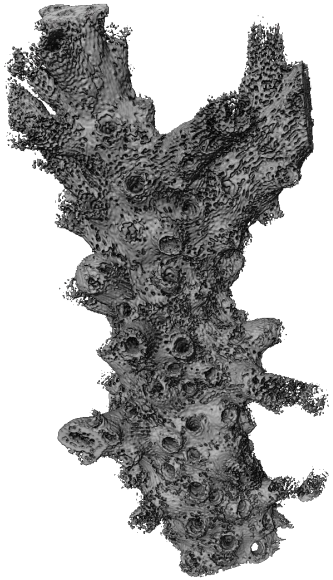


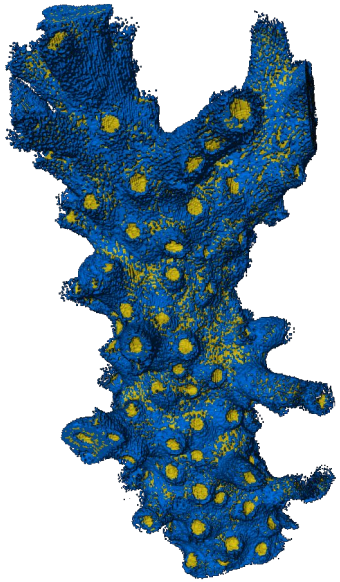


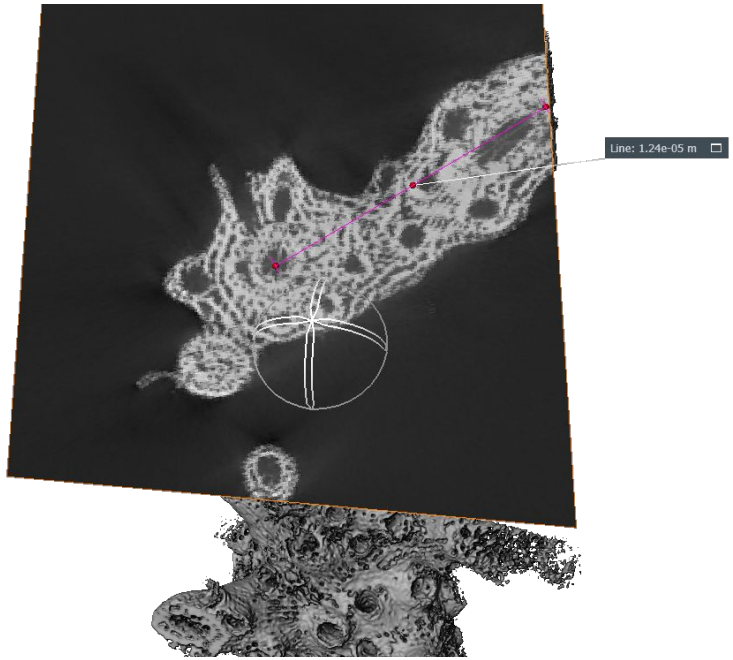


data c/o Dr. Stephen Ogg @
IAC Core Lab

Preview: Computed Tomography (CT) of Coral

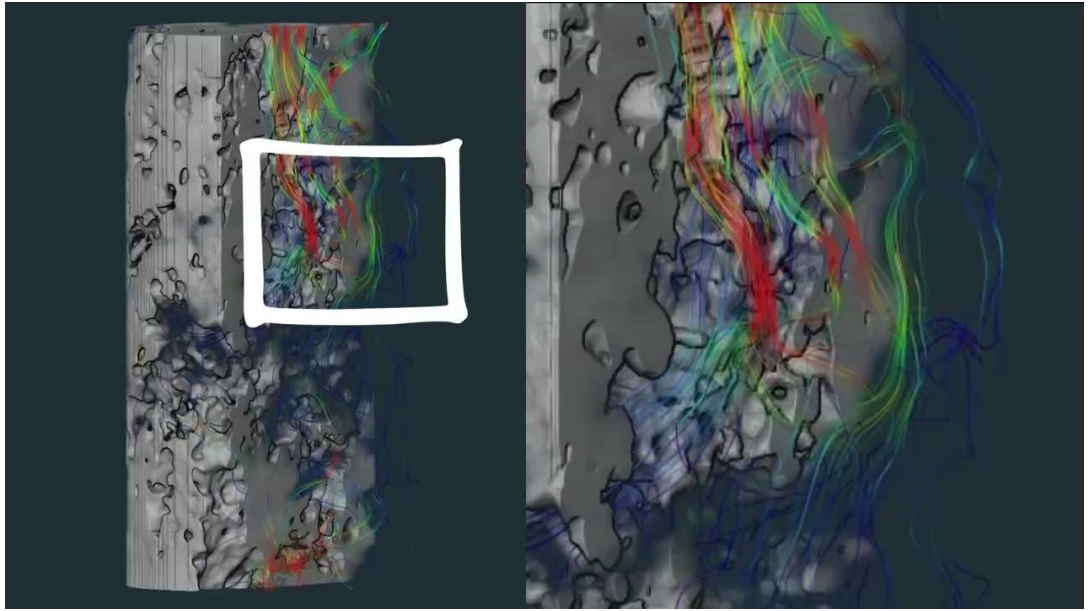


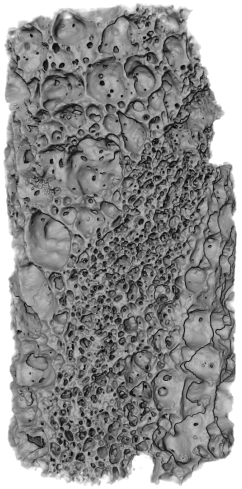


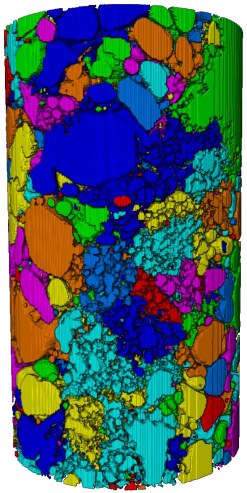


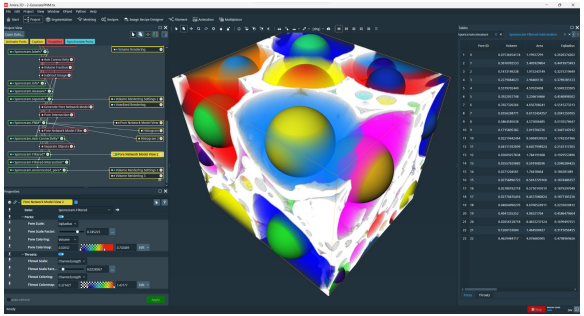
data c/o Domingo Sanchez @ ANPERC

Preview: Computed Tomography (CT) of Core Plug





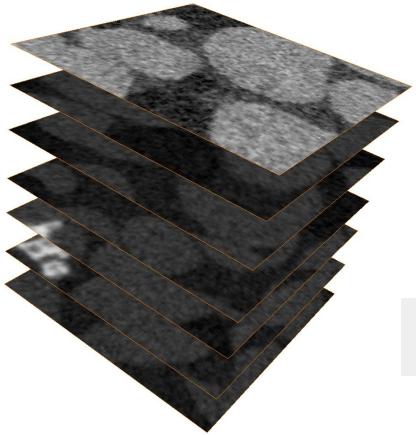




data c/o Zhao Xia @ ANPERC

Workflow overview

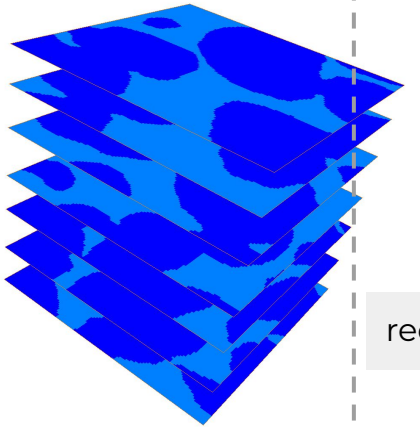
image stack



e.g., 16-bit images
(tiff, png, jpeg)

segmentation

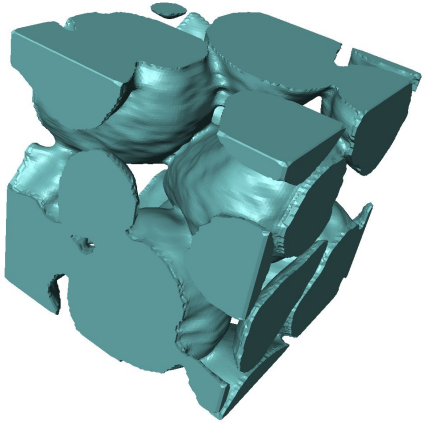
label images



e.g., 8-bit images
(tiff, png)

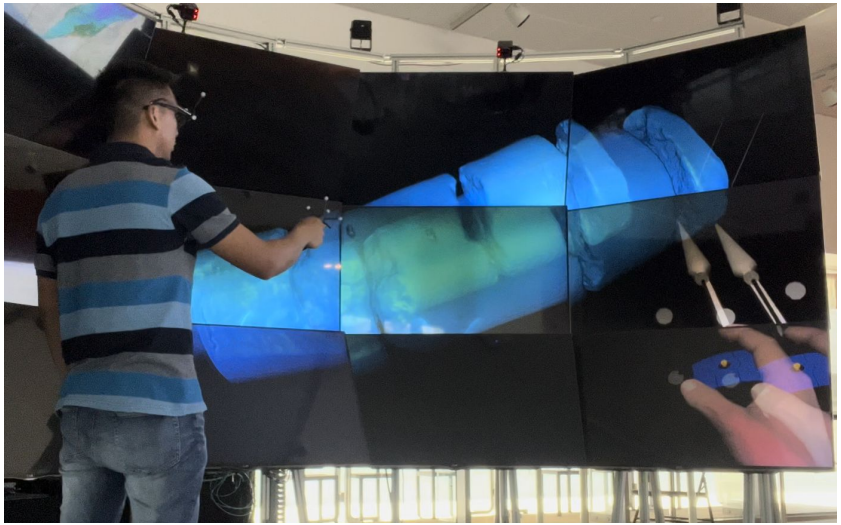
reconstruction

3D model



e.g., triangle mesh
(obj, stl)

3D Visualization

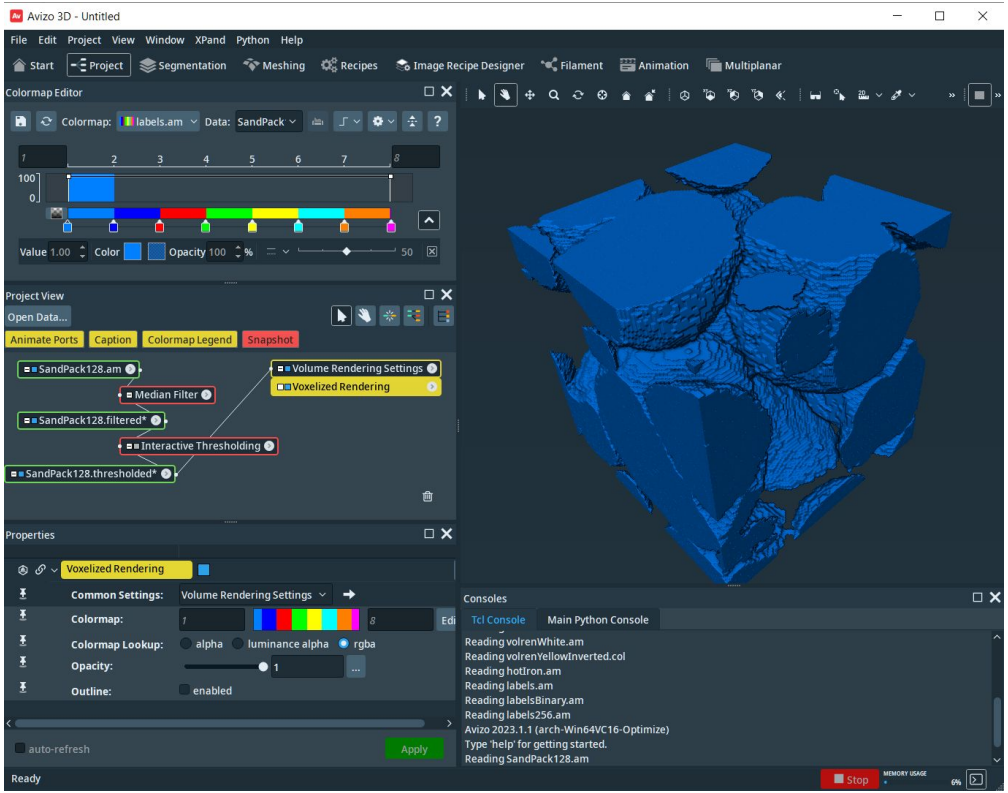


KVL YouTube Channel:
https://www.youtube.com/@kaustvislab

Basic Segmentation using Avizo

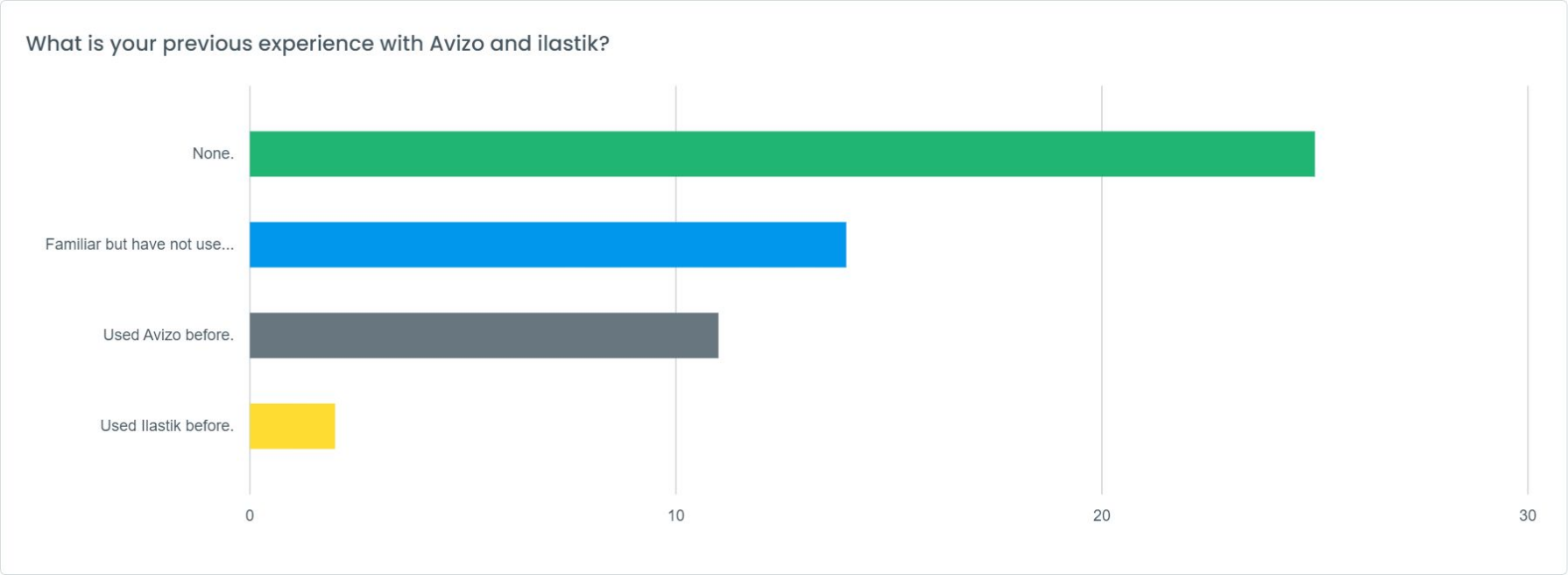
Avizo 2023.1.1

- AI tools requirements:
  - Windows OS
  - Nvidia GPU
  - Deep Learning Environment



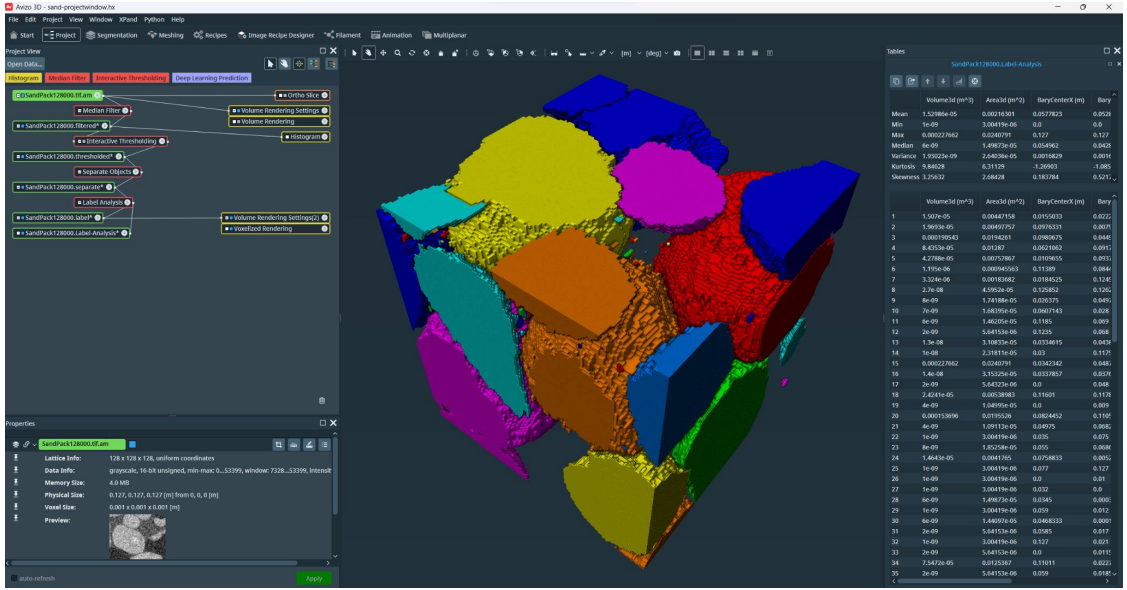
training webpage:
wiki.vis.kaust.edu.sa/training/scivis/2023/avizoilastik

Participants’ experience with Avizo and Ilastik



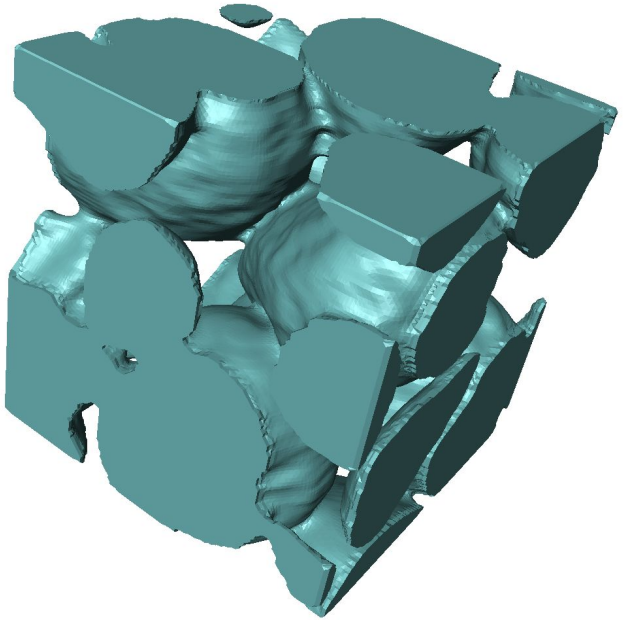
Demo: Sand - Project Window

- Orthoslice
- Volume Rendering
- Interactive Thresholding
- Median Filter
- Voxelized Rendering
- Separate Objects
- Label Analysis



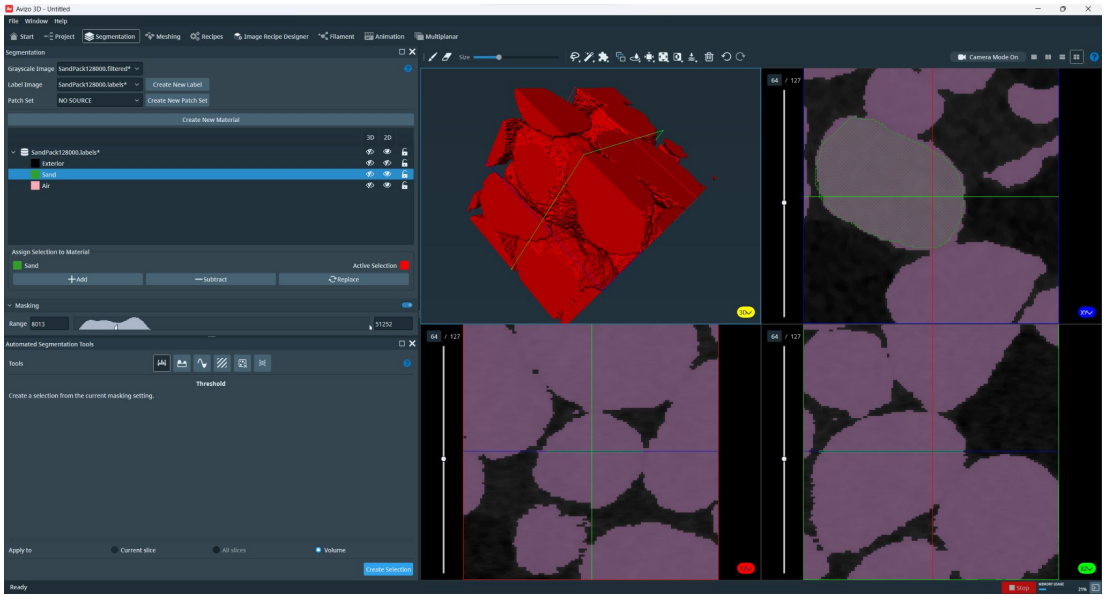
Hands-on: Sand - Project Window

- Orthoslice
- Volume Rendering
- Interactive Thresholding
- Median Filter
- Volume Fraction
- Separate Objects
- Label Analysis
- Voxelized Rendering



Demo: Sand - Segmentation Workroom

- Set input data (filtered)
- Create new label
- Create new materials
- Create and add selections to material:
  - Using brush
  - Using threshold tool



Hands-on: Sand - Segmentation Workroom

- Set input data (filtered)
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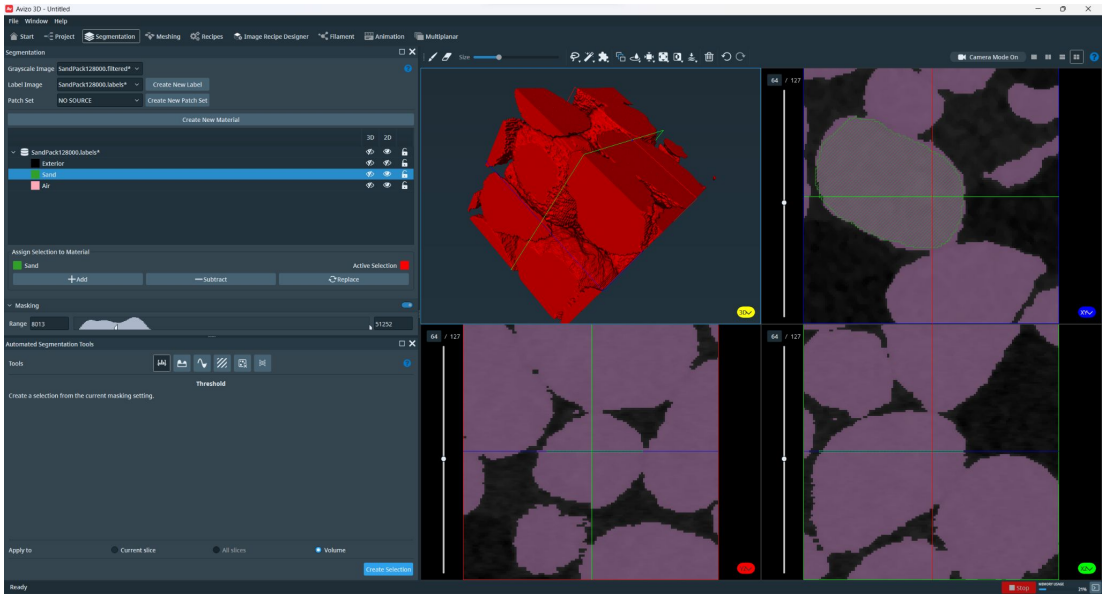
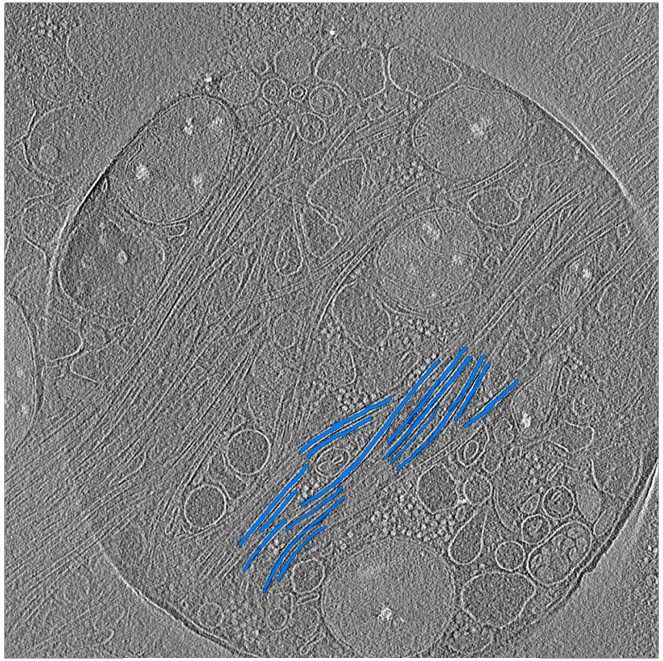


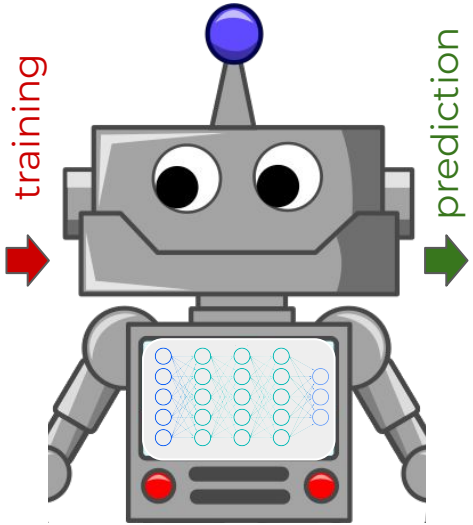
AI-Assisted Segmentation using Avizo

Important AI concepts

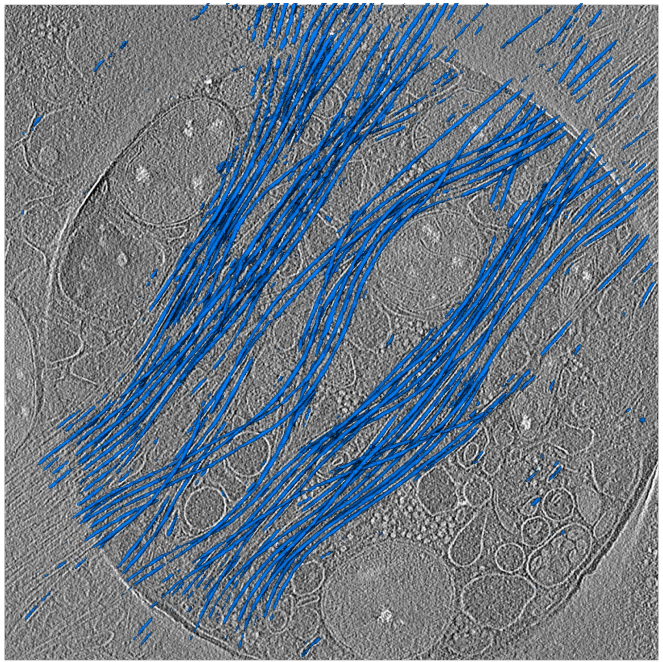
We will focus on using **deep learning models** for segmentation.



human segmentation



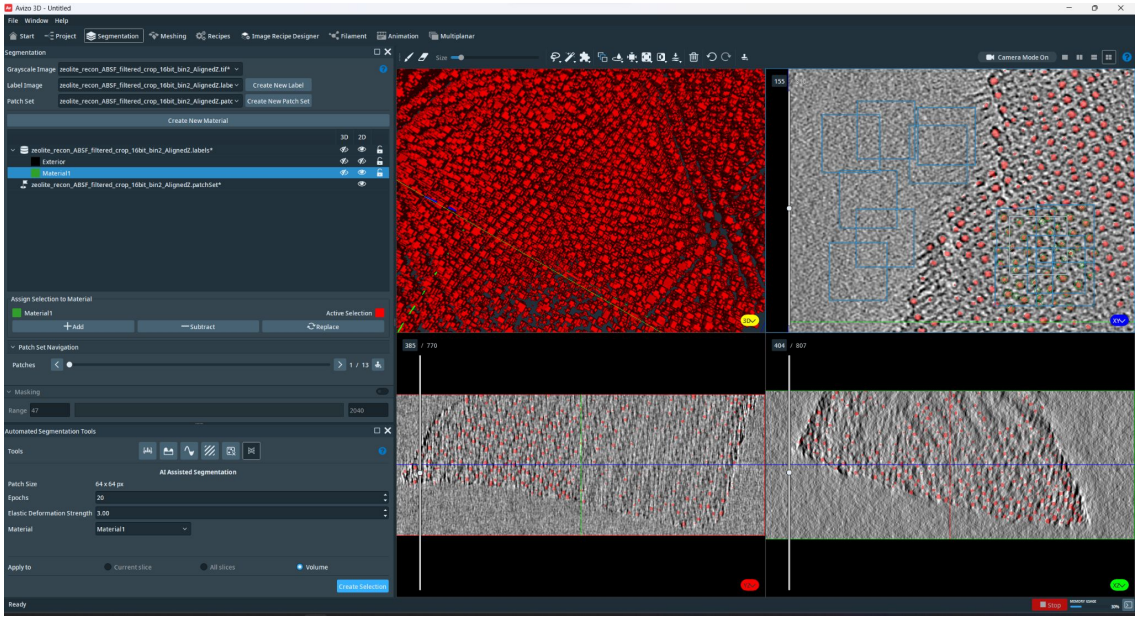
deep learning model
(AI)



AI segmentation

Demo: Zeolite - Segmentation Workroom

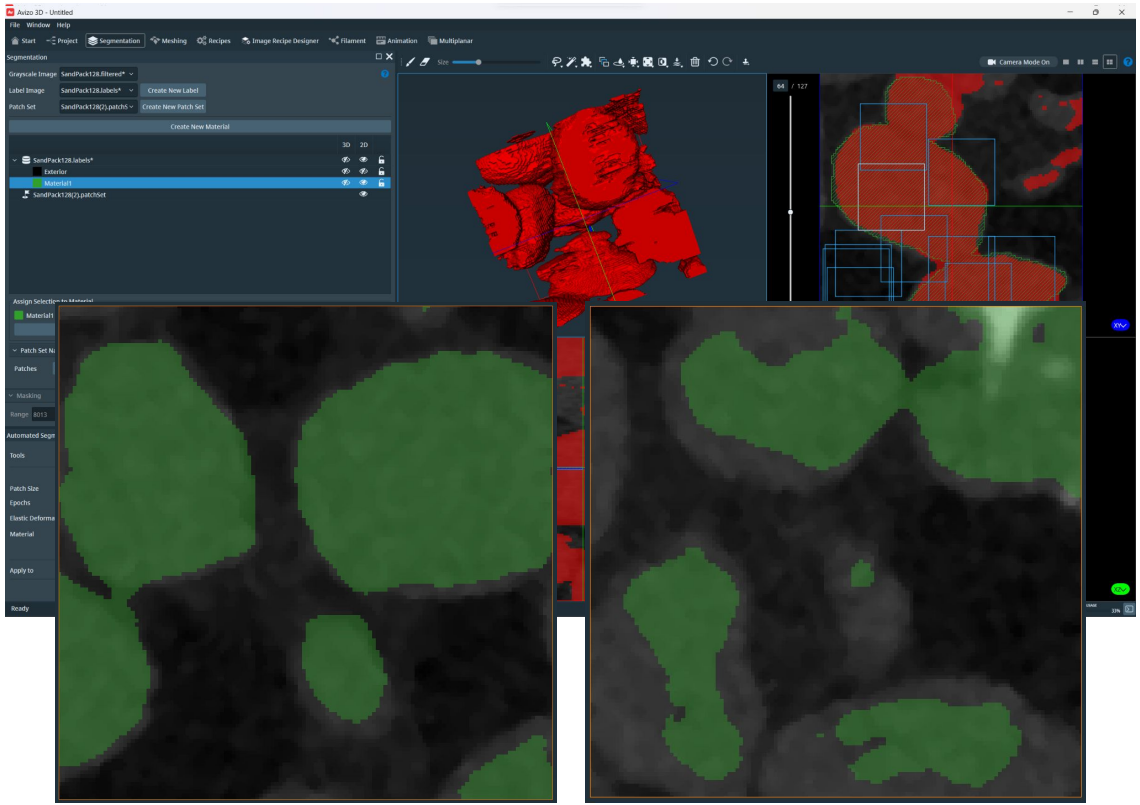
- Set input data
- Create new label
- Create new materials
- Add selections to material using brush
- Create new patch set
- Add patches for fore/background
- Create/add selection using AI tool
- Tweak parameters and iterate



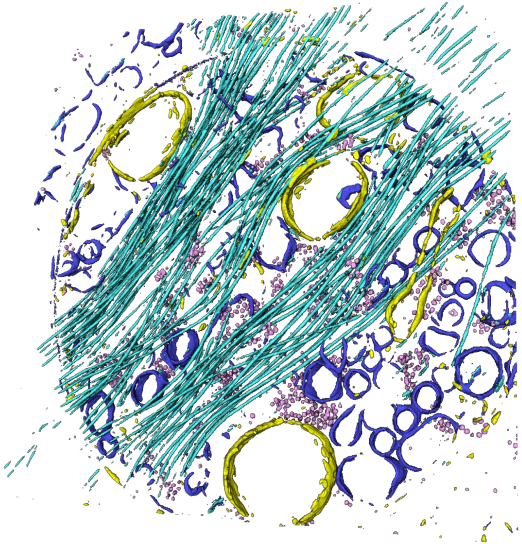
data c/o Georgian Melinte @IAC Core Lab
(Parsapur et. al, 2023)

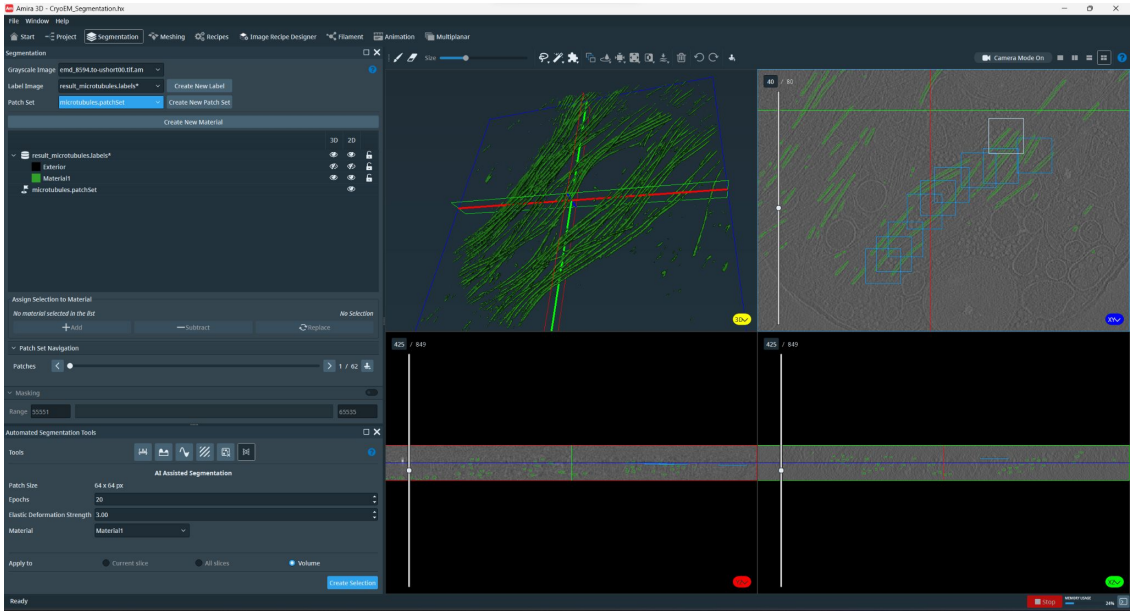
Example: Sand - Segmentation Workroom

- Set input data (filtered)
- Create new label
- Create new materials
- Add selections to material using brush
- Create new patch set
- Add patches for fore/background
- Create/add selection using AI tool
- Tweak parameters and iterate



Hands-on: CryoEM - Segmentation Workroom





See CryoEM folder in datasets. Input data is CryoEM/CryoEM_Segmentation-files/emd_8594.to-ushort00.tif.

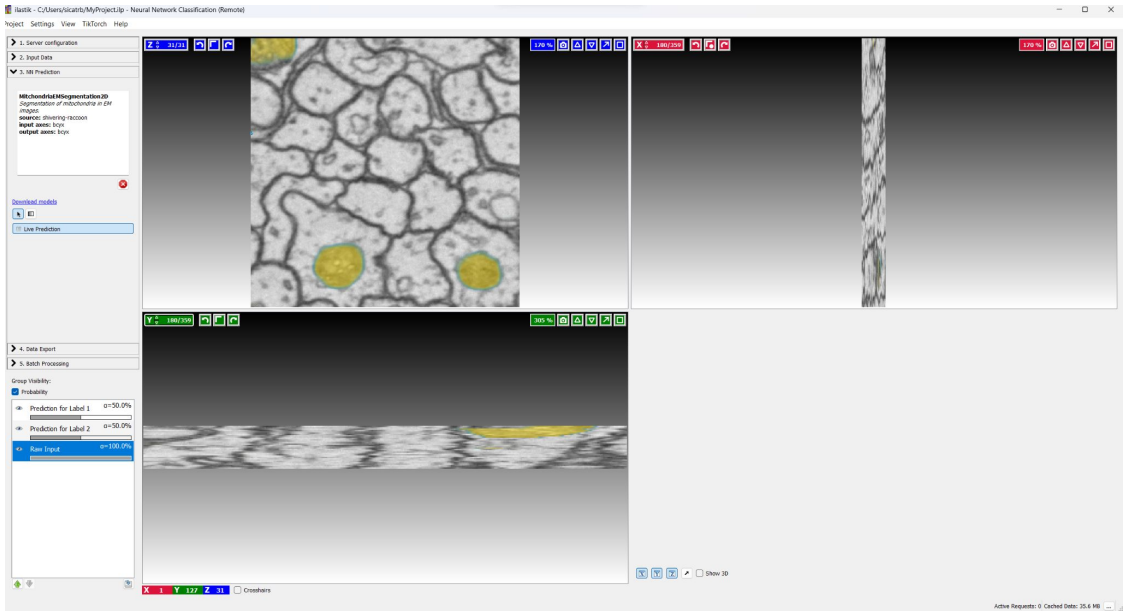
https://xtras.amira-avizo.com/xtras/ai-assisted-tool-for-cryoem-segmentation

Break (15 Minutes)

AI-Assisted Segmentation using Ilastik

Ilastik 1.4.0

- Advantages:
  - Cross platform
  - CPU or GPU
  - Free and open source



training webpage:
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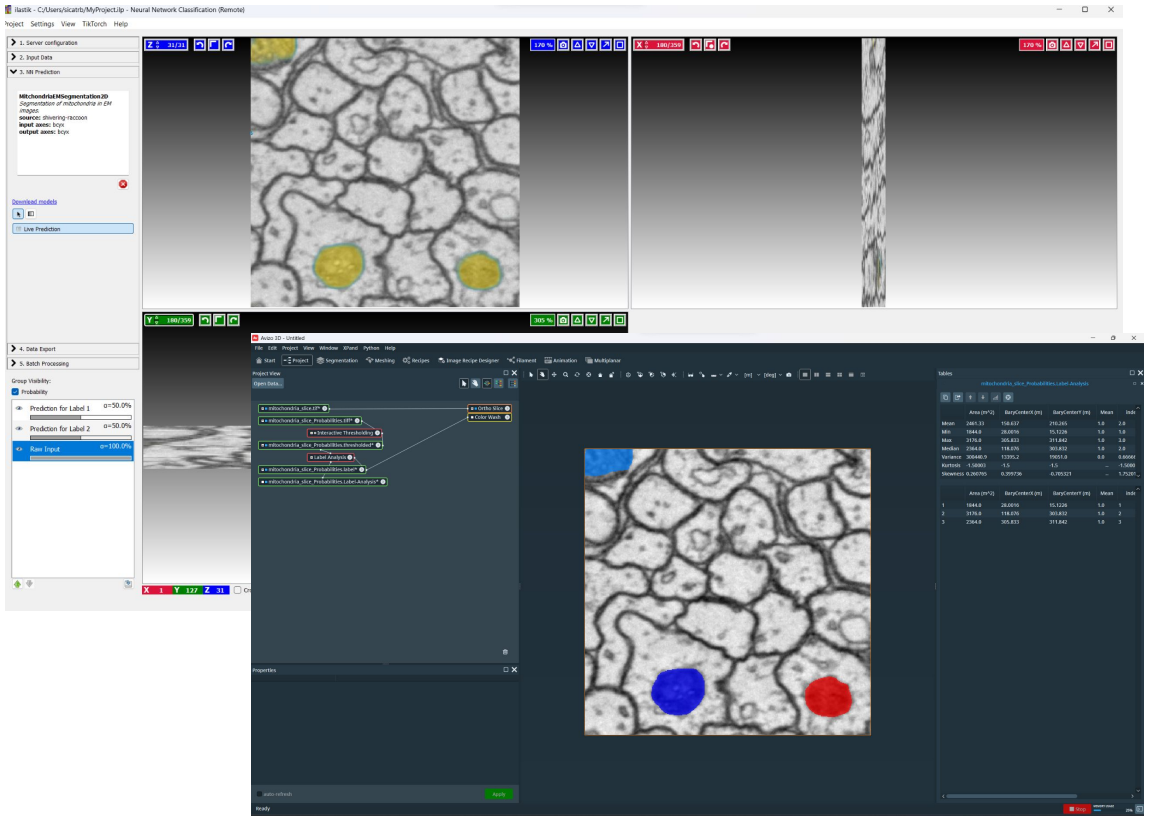
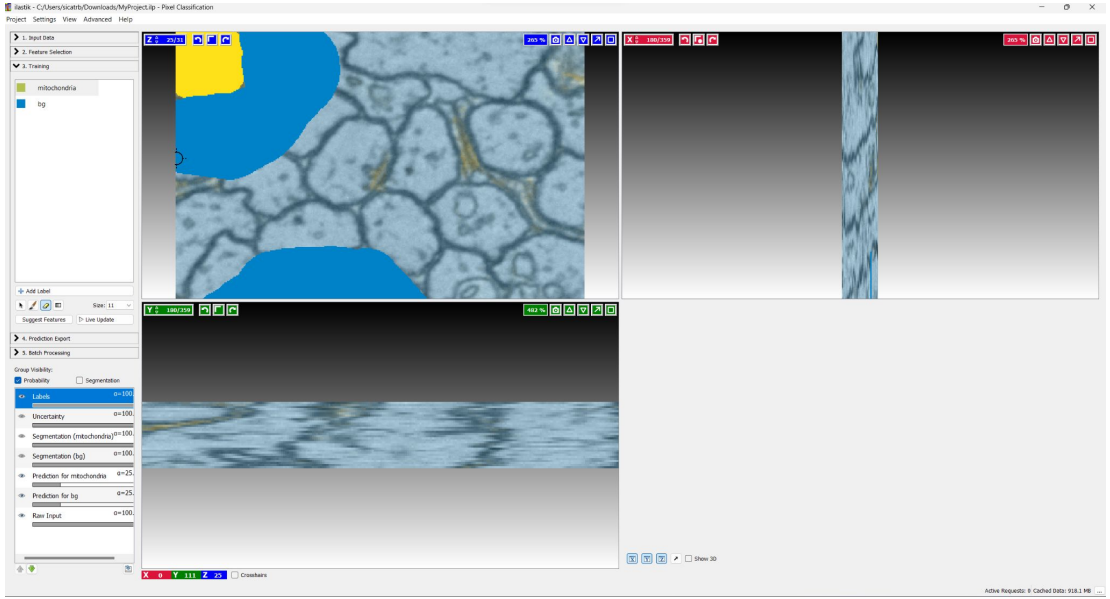
Hands-on: Mitochondria (Neural Net Classification)

- Load data (slice)
- Select model from zoo (shivering-raccoon)
- Load model
- Apply model
- Export results
- Load in Avizo

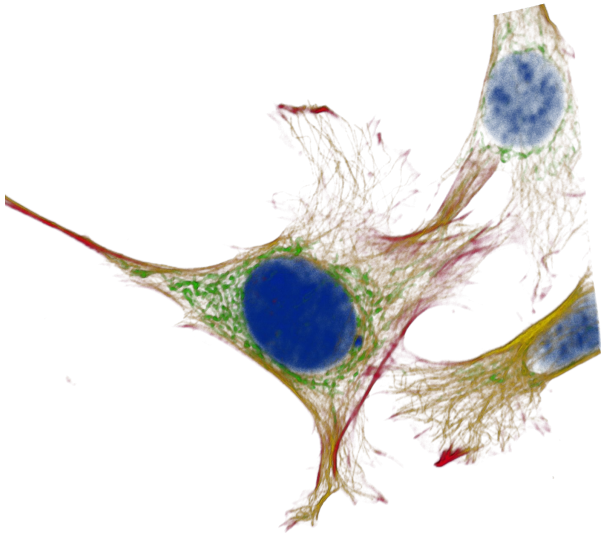


Hands-on: Mitochondria (Pixel Classification)

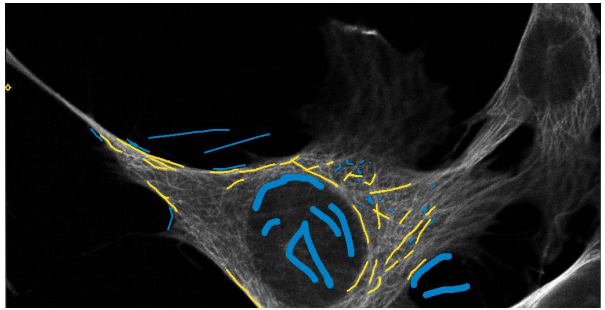
- Load data (stack)
- Create Labels
- Run prediction
- Export results
- Load in Avizo



Example: Confocal Microscopy of Cell

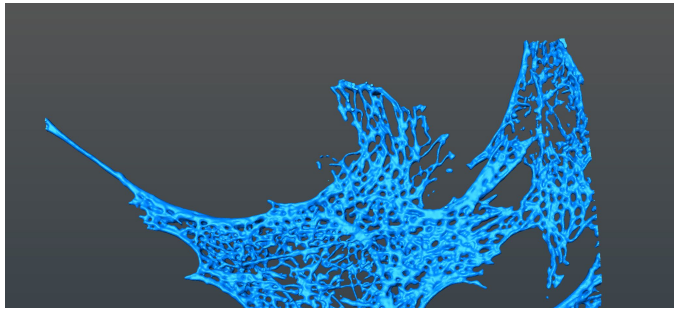


data c/o Dr. Stephen Ogg @ IAC Core Lab



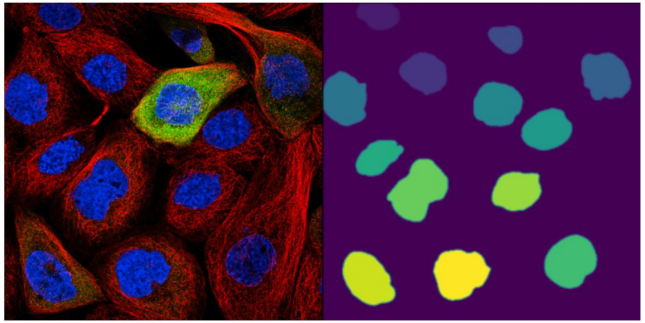
downloads 23129 license CC-BY-4.0

10.5281/zenodo.6200999 conscientious-seashell

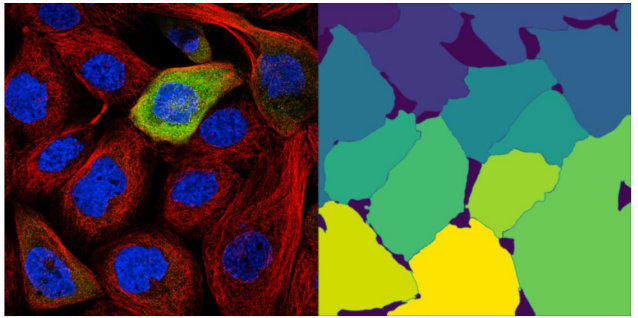


downloads 27137 license CC-BY-4.0

10.5281/zenodo.6200635 loyal-parrot



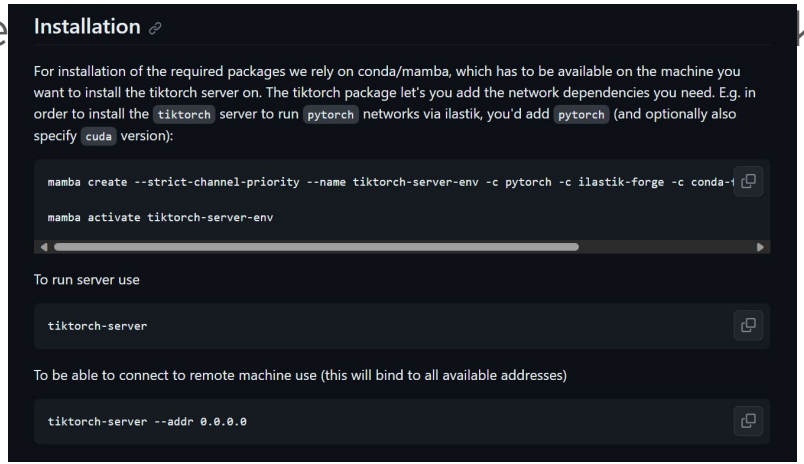
Contributors: Hao Xu Wei Ouyang



Contributors: Hao Xu Wei Ouyang

Hands-on: Cell nucleus

- Install miniforge- https://github.com/conda-forge/miniforge/releases
- Run “Miniforge Prompt”
- Go to: https://github.com/ilastik/tiktorch
- Run installation instructions (screenshot below) on prompt (if using cuda, replace cuda>=11.3 with cuda=11.8 (remove >).
- Run neural ne kflow on ilastik.



Installation

For installation of the required packages we rely on conda/mamba, which has to be available on the machine you want to install the tiktorch server on. The tiktorch package let's you add the network dependencies you need. E.g. in order to install the `tiktorch` server to run `pytorch` networks via ilastik, you'd add `pytorch` (and optionally also specify `cuda` version):

```
mamba create --strict-channel-priority --name tiktorch-server-env -c pytorch -c ilastik-forge -c conda-
mamba activate tiktorch-server-env
```

To run server use

```
tiktorch-server
```

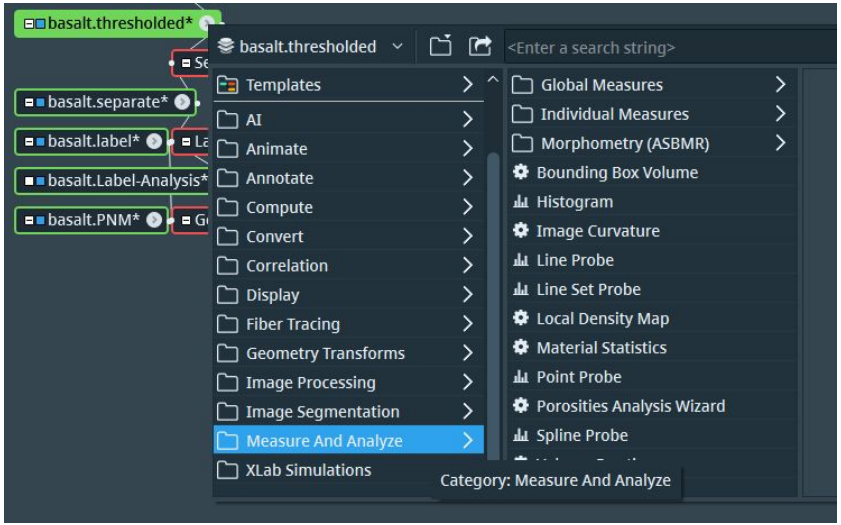
To be able to connect to remote machine use (this will bind to all available addresses)

```
tiktorch-server --addr 0.0.0.0
```

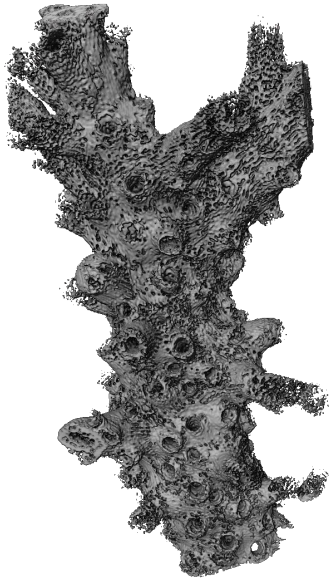
Common Analysis Workflows

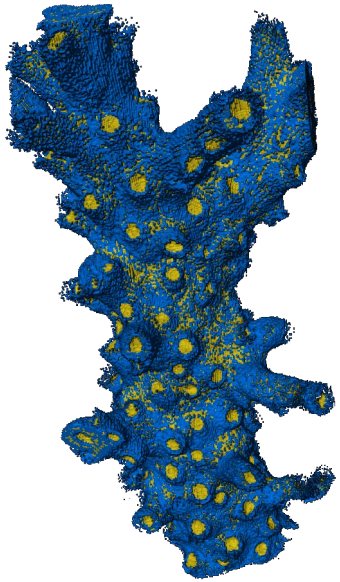
Avizo measurement and analysis modules

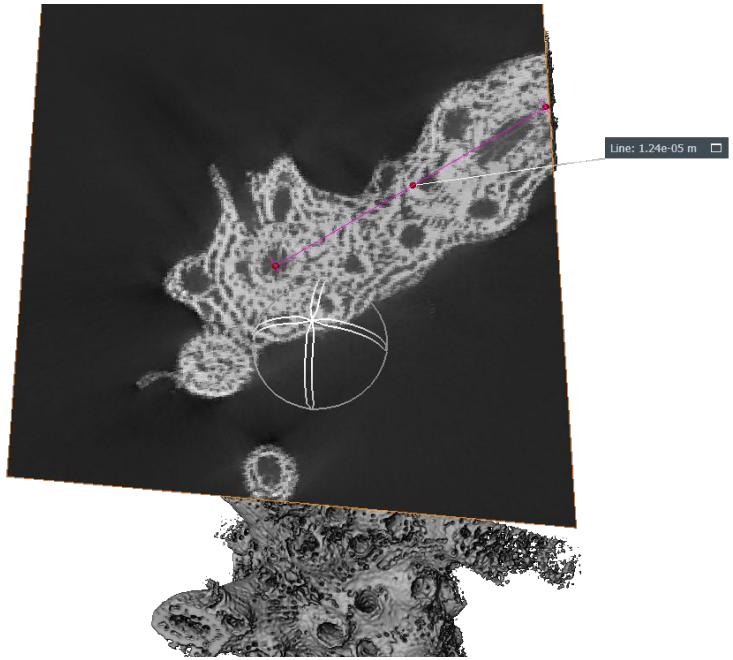
- Measurement
- Histogram
- Volume Fraction
- Arithmetic
- Separate Objects
- Label Analysis
- Filter by Measure
- See “Measure and Analyze” category



Hands-on: CT of Coral

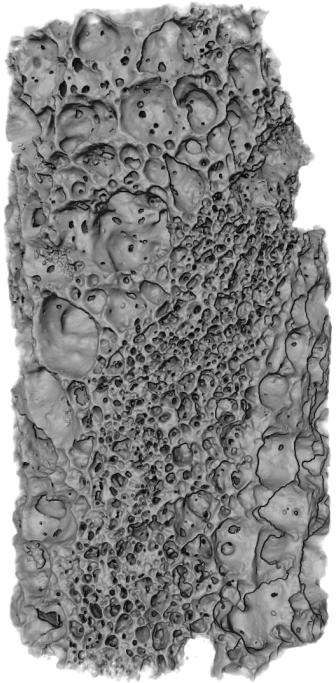


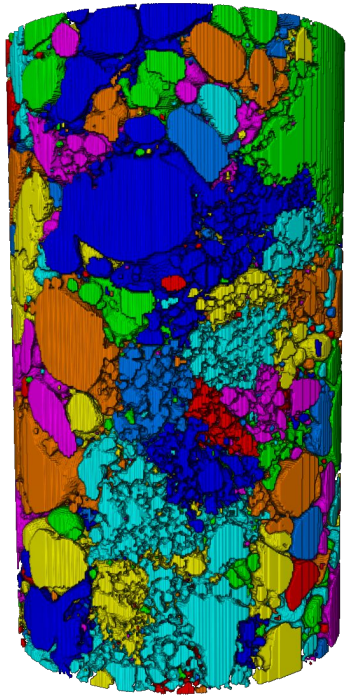




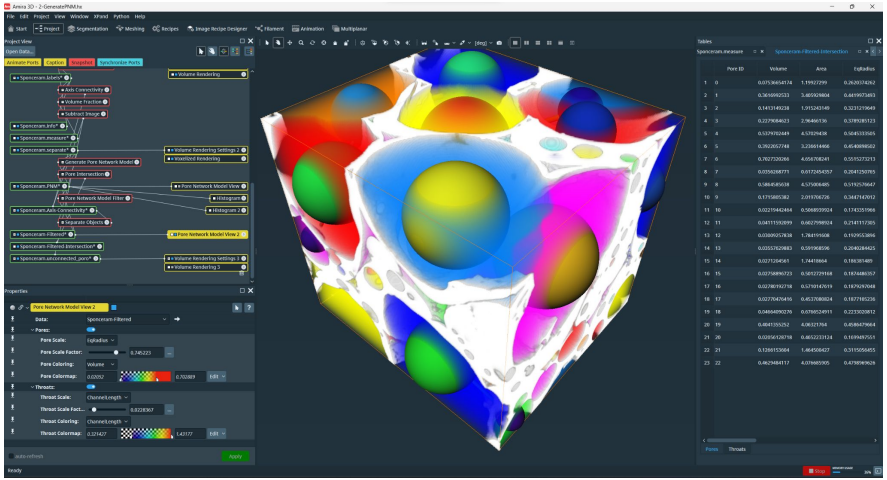
data c/o Domingo Sanchez @ ANPERC

Hands-on: CT of Basalt Core Plug





data c/o Zhao Xia @ ANPERC

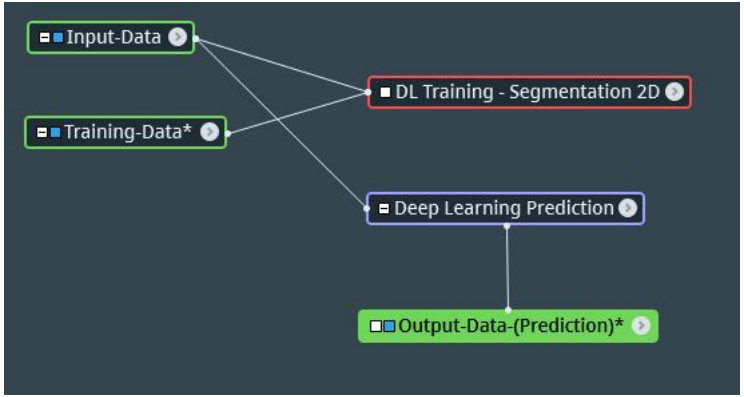


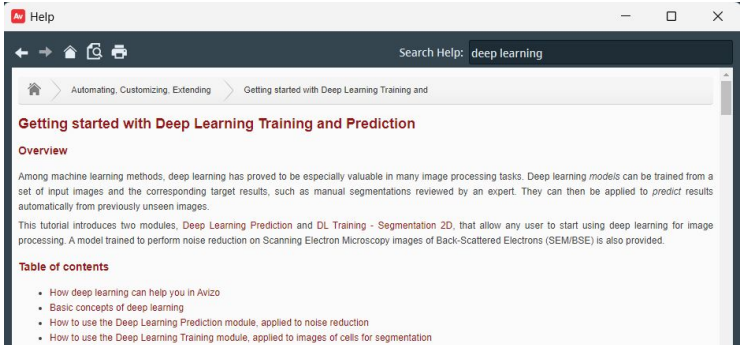
See PNM folder in datasets for Pore Network Model example. Search for “Avizo Pore Network Modeling” in YouTube.

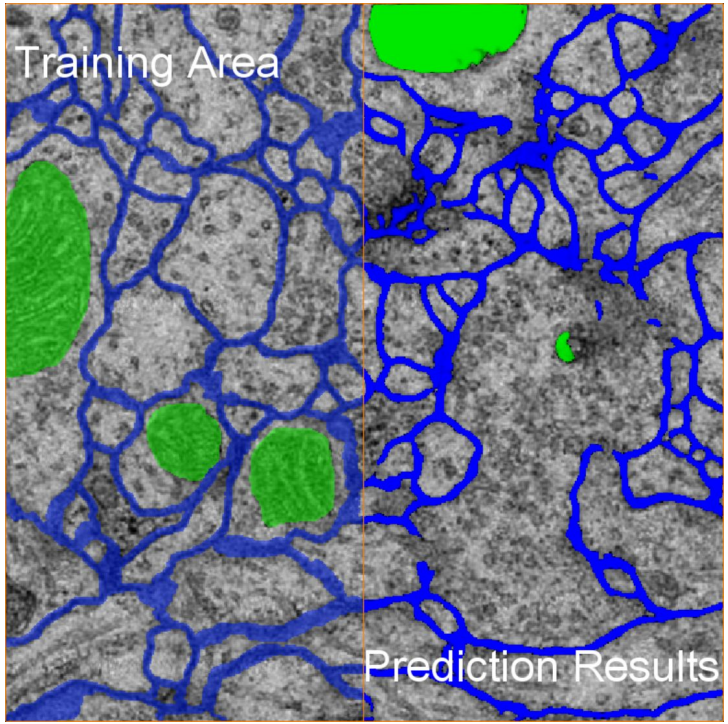
Workflow recommendation

- Inspect data (orthoslice, volume rendering, histogram)
- Filter data to denoise or improve features:
  - Median filter, Bilateral filter, Non-local means filter
- Try simple segmentation tools in Avizo:
  - Thresholding, Watershed, Texture Classification
- Try **AI segmentation in Avizo**
- Try **AI segmentation in Ilastik**
- Try Pixel Classification in Ilastik
- Try Deep Learning Training/Prediction in Avizo
- Try other tools
- Worst case: manual segmentation
- Not sure? Contact **help@vis.kaust.edu.sa**.

Deep Learning Training/Prediction in Avizo



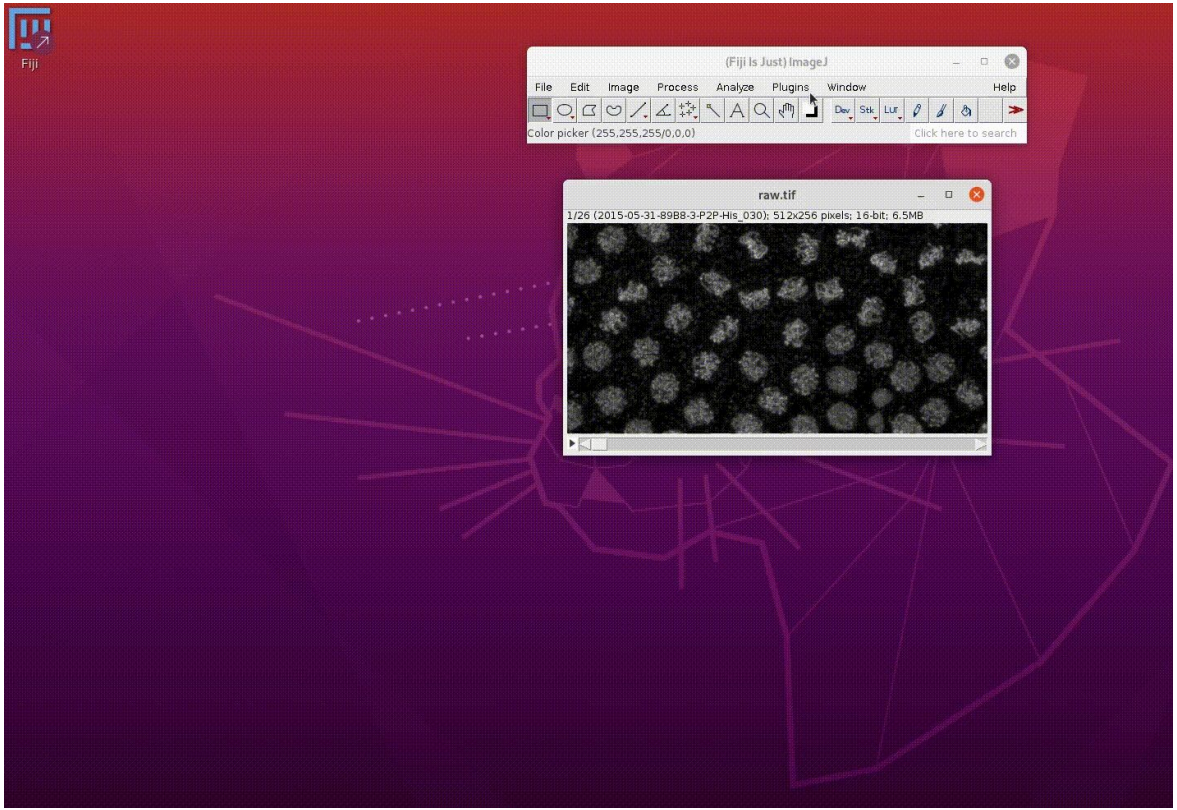




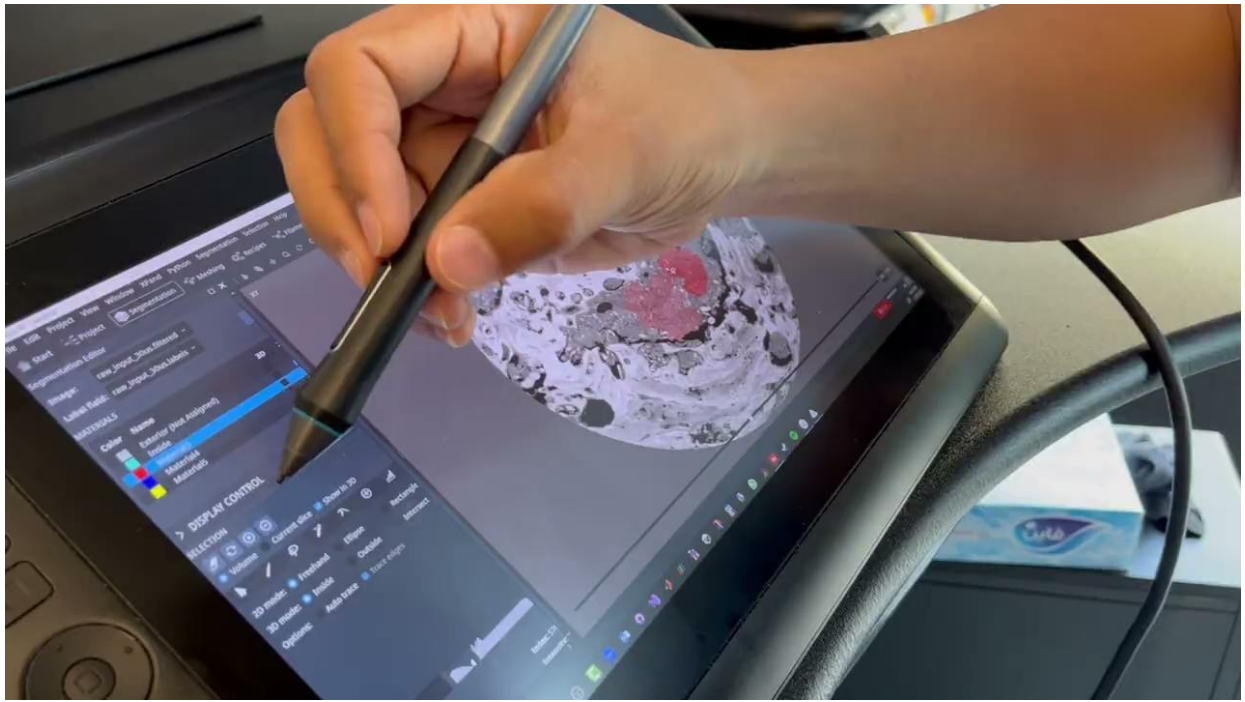
https://xtras.amira-avizo.com/xtras/getting-started-with-deep-learning-training

Other segmentation tools

- Fiji
- Matlab
- OpenCV
- TensorFlow
- PyTorch



Manual segmentation



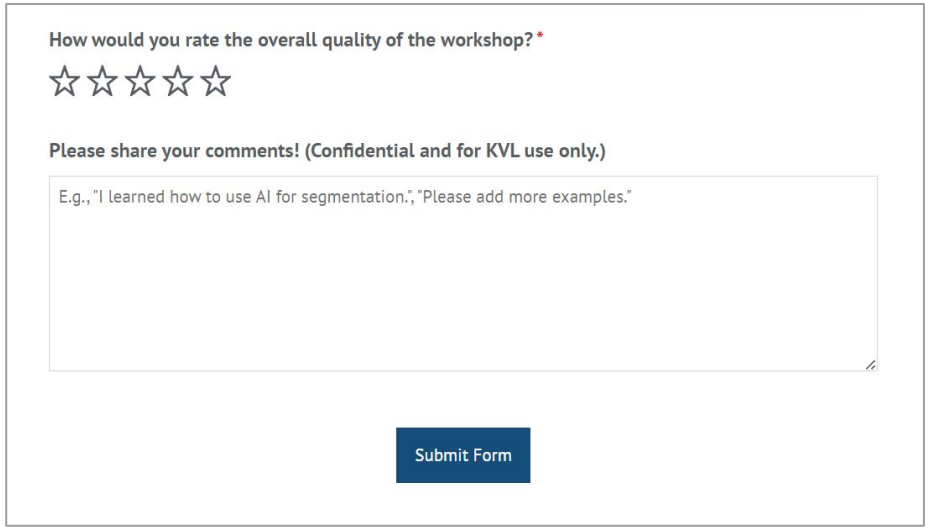
Book “Vive” facility at https://wiki.vis.kaust.edu.sa/booking.

Thank you!

wiki.vis.kaust.edu.sa

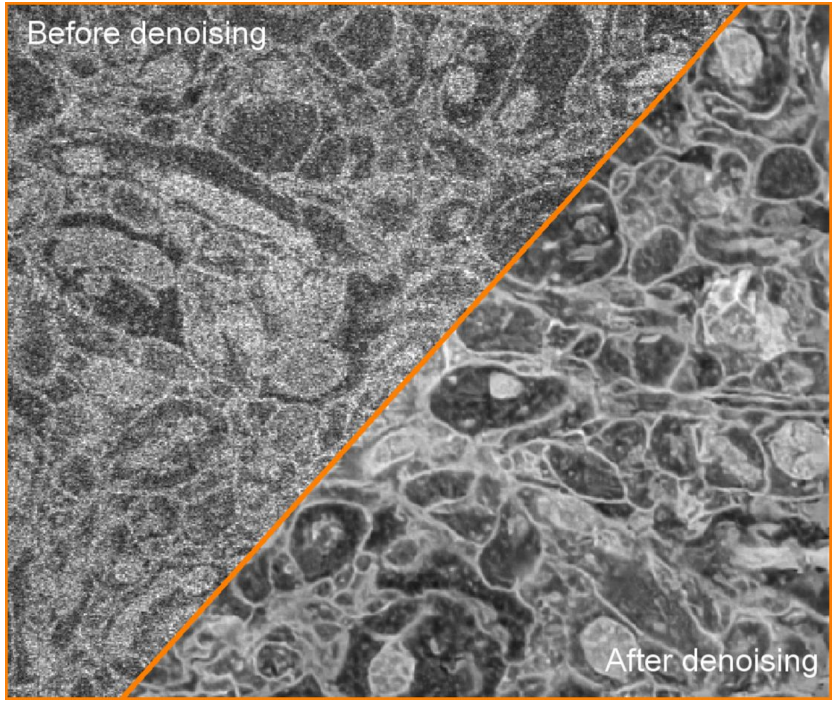
help@vis.kaust.edu.sa

feedback form

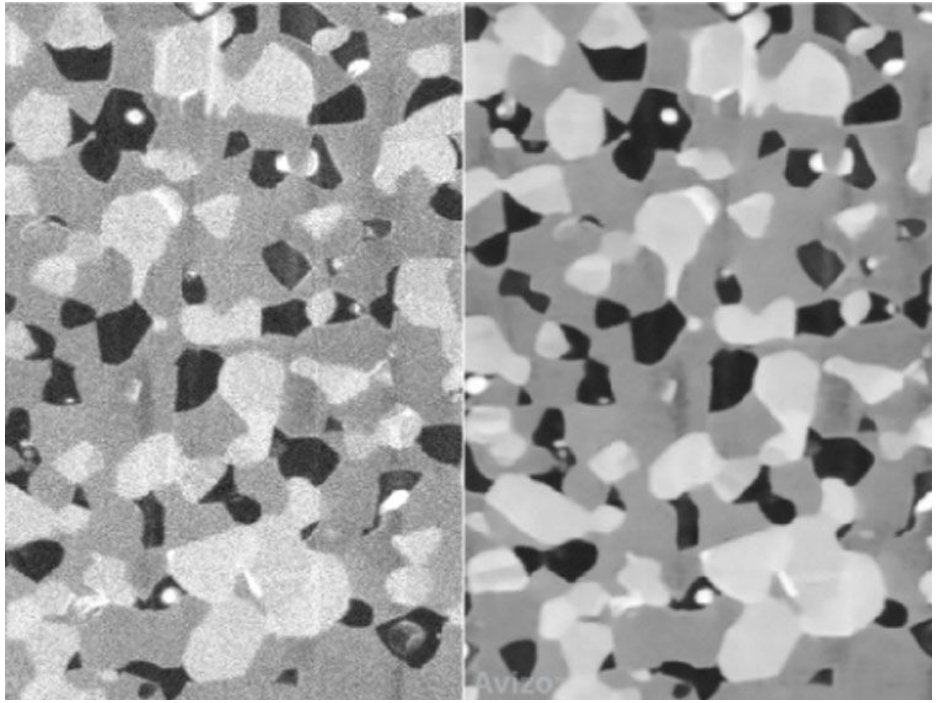


End

Denoising using Deep Learning



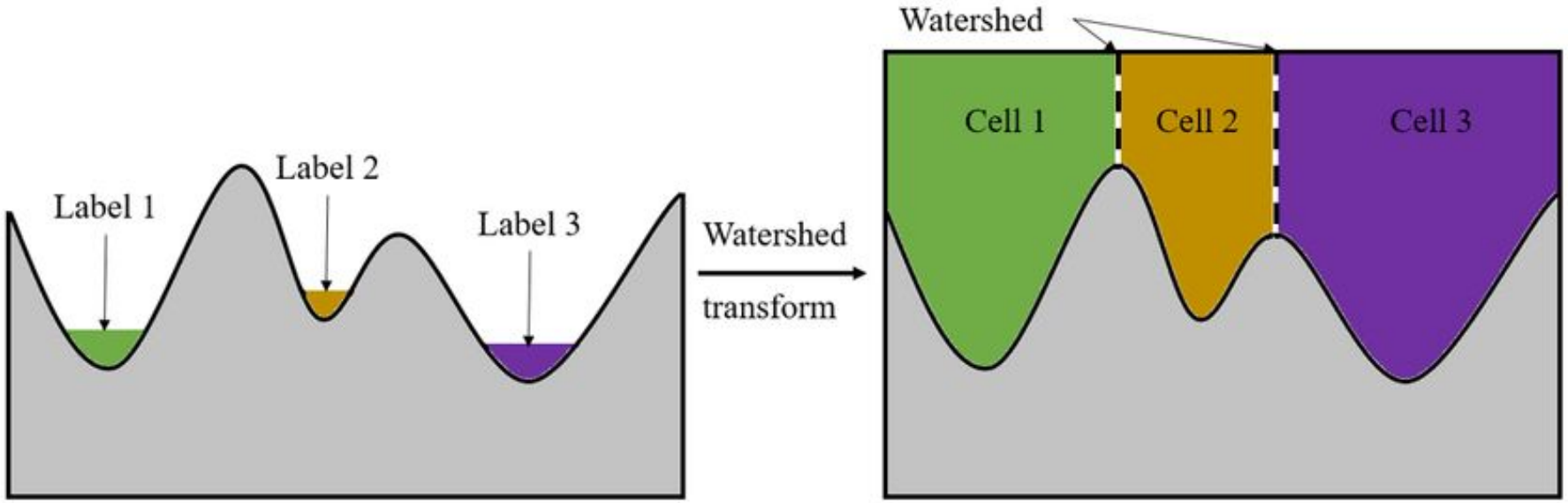
https://xtras.amira-avizo.com/xtras/bse-sem-denoiser



Noise to Void

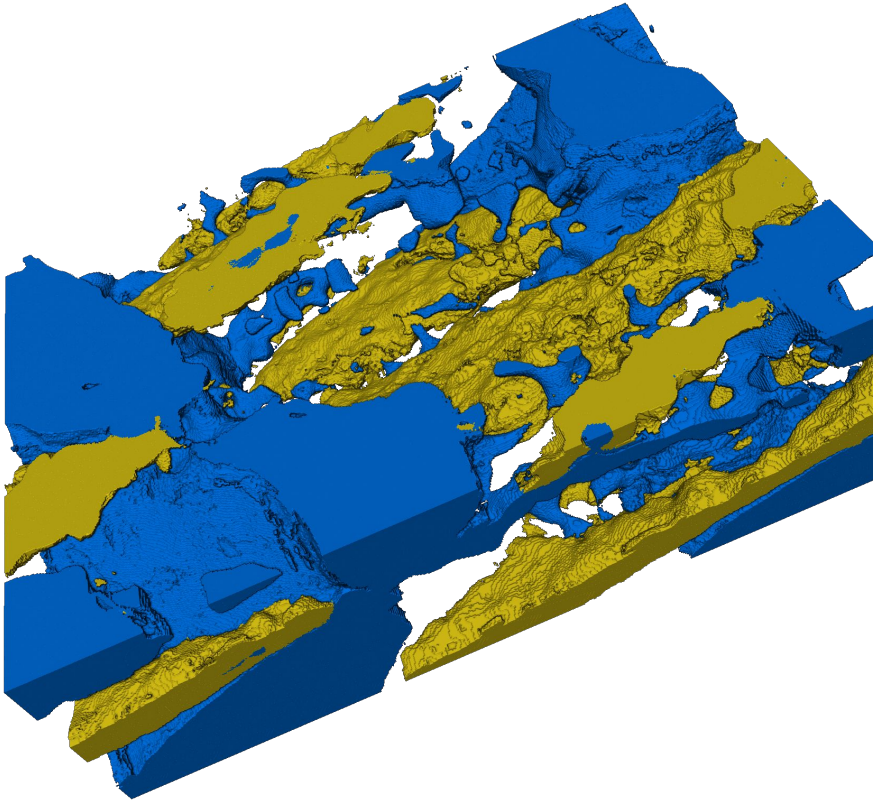
Hands-on: Bottle (watershed)

Watershed algorithm

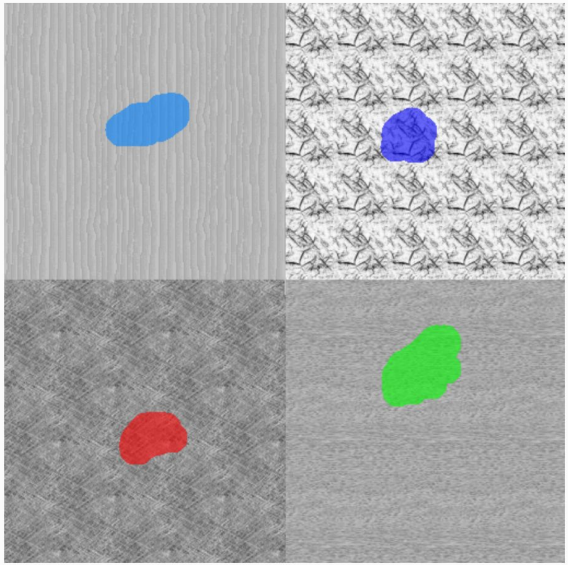


https://www.researchgate.net/figure/The-segmentation-process-of-the-watershed-algorithm_fig2_349323744

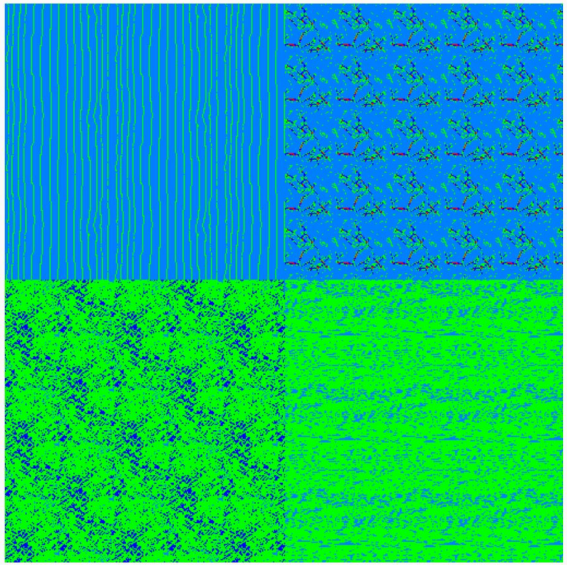
Hands-on: Heart (texture classification)



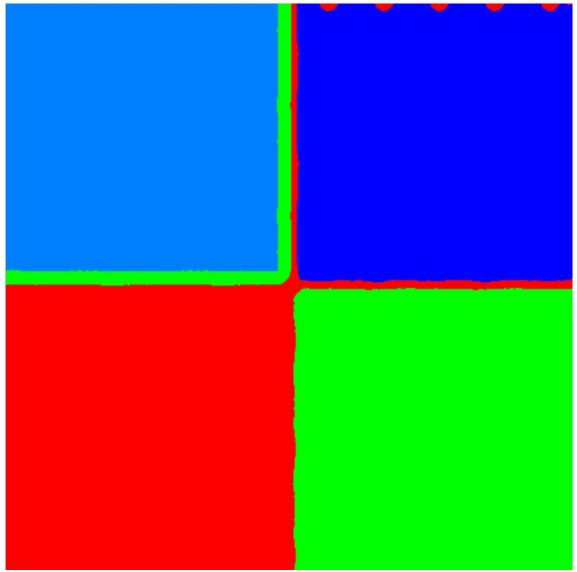
Texture classification



input + training data

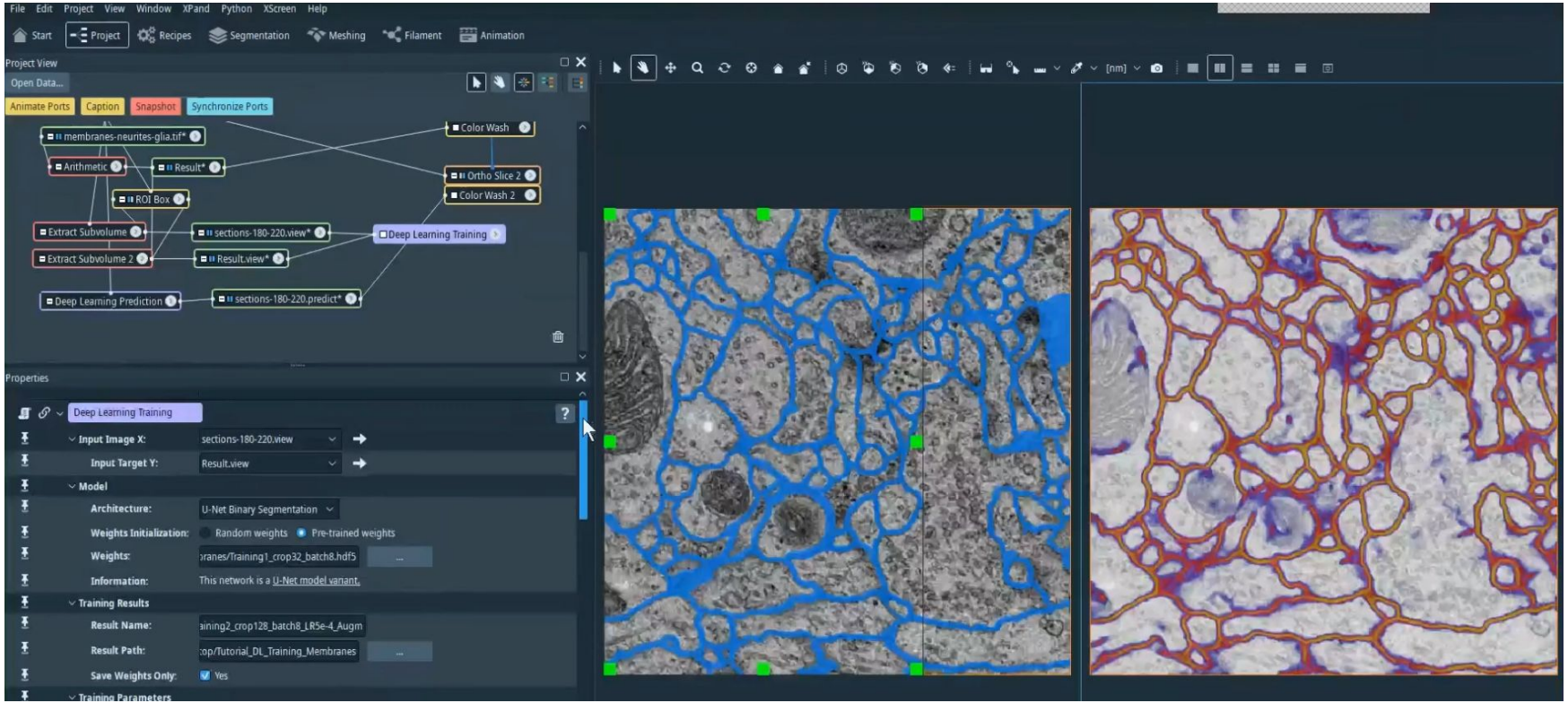


thresholding result



texture classification result

Deep Learning in Avizo



https://www.youtube.com/watch?v=4mSflaGKNbI