Reproducible image analysis workflows with OMERO

Workshop: **Research Data Management for Microscopy and BioImage Analysis**

Sep 26th, 2024, Module 3

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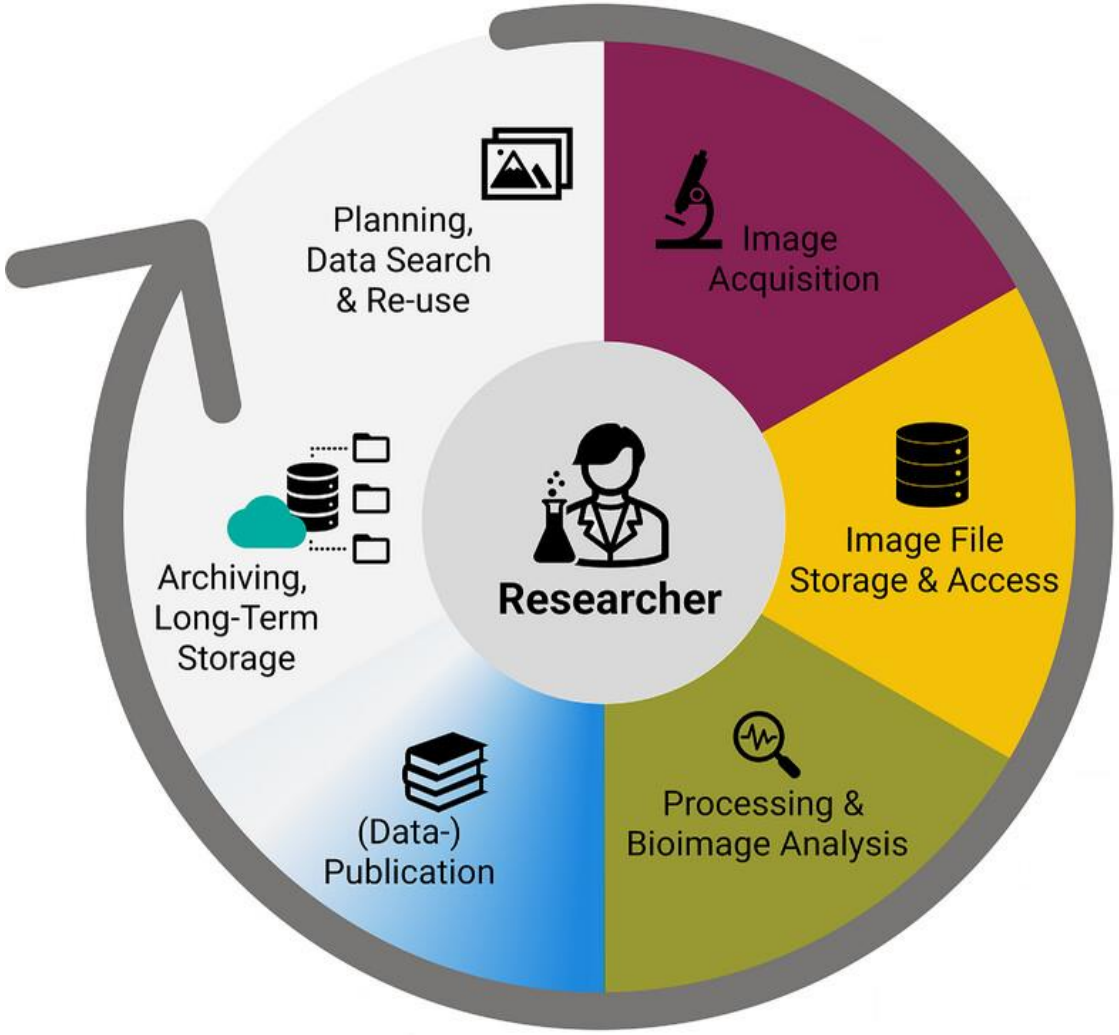
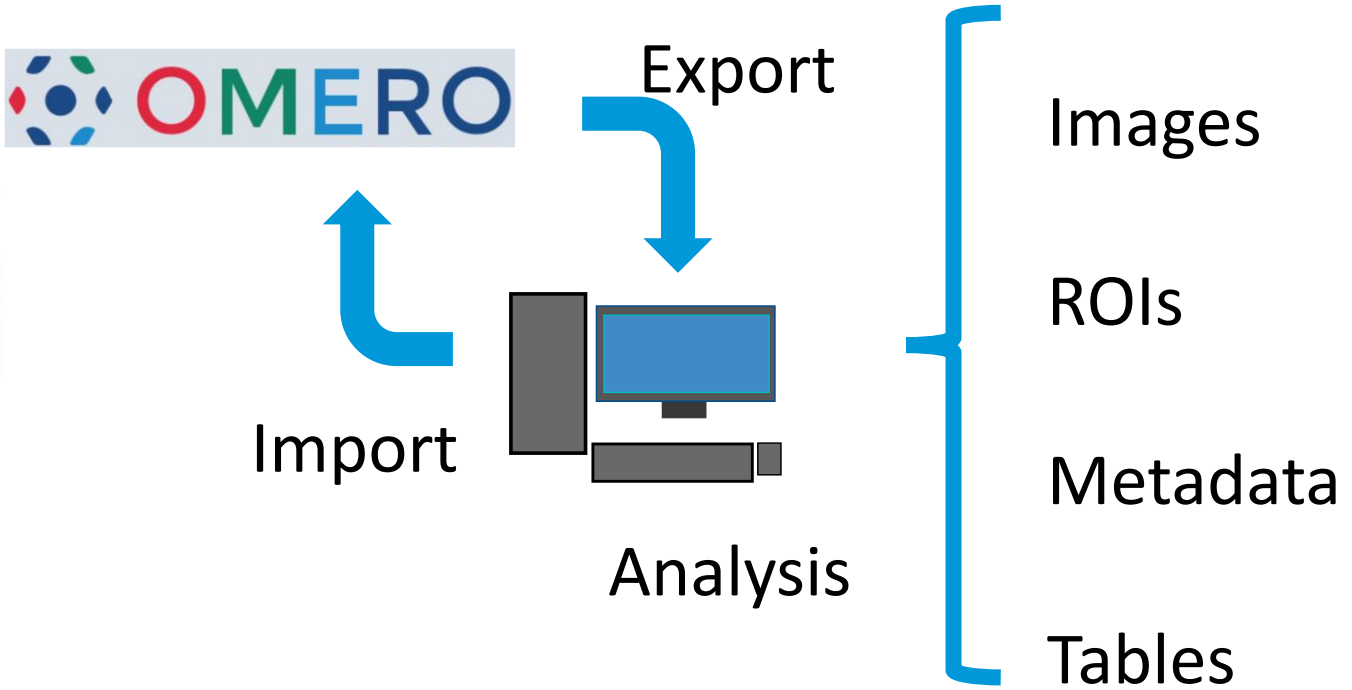
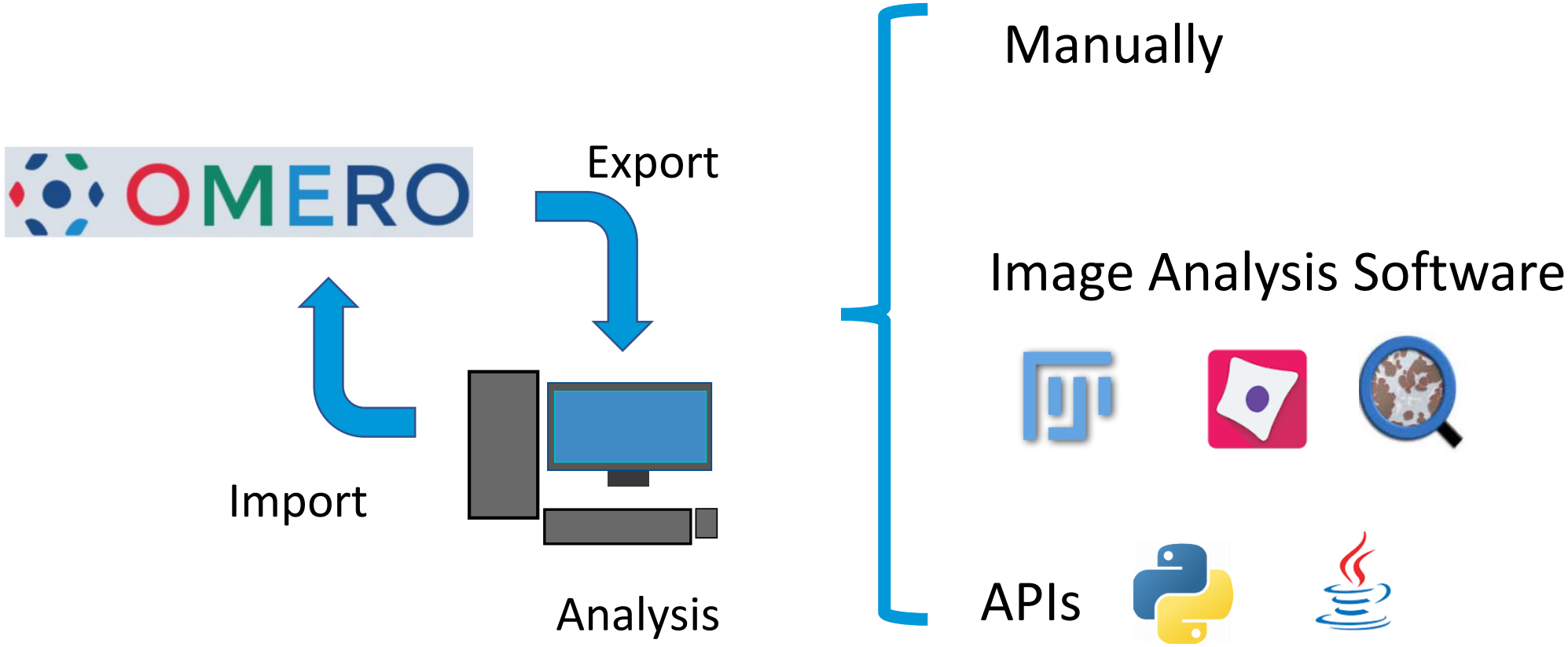
Analysis in the data management workflow





A practical guide to bioimaging research data management in core facilities, Journal of Microscopy, Volume: 294, Issue: 3, Pages: 350-371, First published: 16 May 2024, DOI: (10.1111/jmi.13317)

Getting Data/Metadata from/to OMERO



Not here to recommend specific tools, but to give ideas on how to use your favourite tools for reproducible workflows.

OMERO and image analysis tools

Non Exhaustive list of tools able to connect to OMERO directly or through plugins:

Fiji

napari

TrackMate

CellProfiler

Orbit

FLIMFIT

QuPath

Ilastick

Knime-knip

https://www.openmicroscopy.org/omero/features/analyze/
https://omero-guides.readthedocs.io/en/latest/external_tools.html

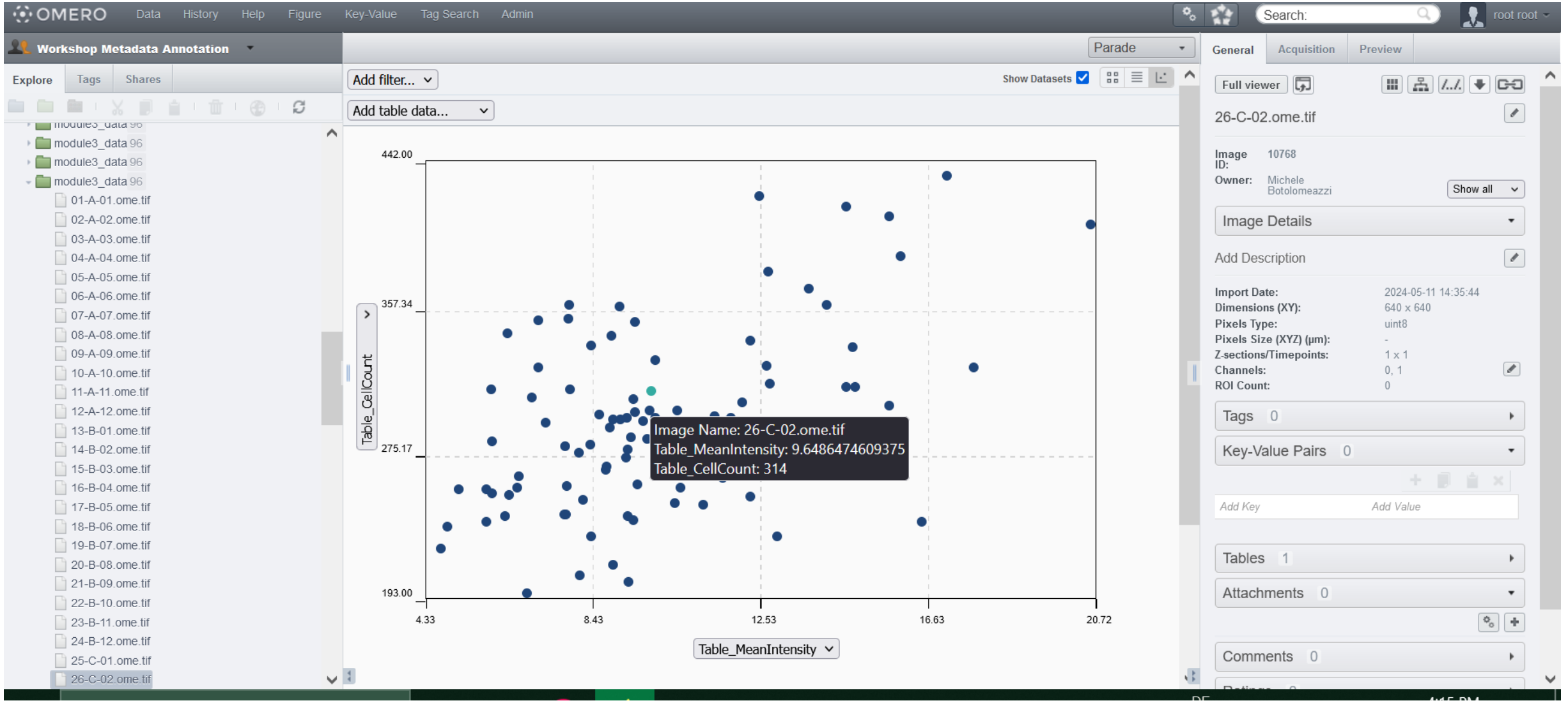
Using analysis software reproducibly

- Use/record macros and share them (add the macro or a link to the repository to OMERO) e.g. https://github.com/German-BioImaging/fiji_omero_workflows
- Keep track of software + plugin versions
- Reupload results to OMERO including:
  - ROIs
  - Tables
  - Images

It will make the upload to a public repository a lot easier!

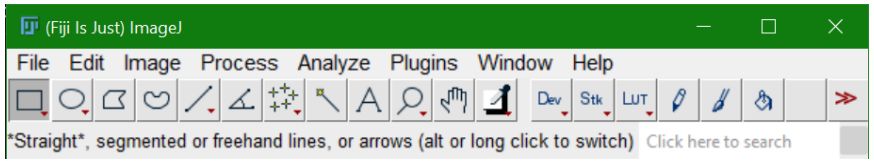
In vivo application of a glutaraldehyde-free, UVA/riboflavin cross-linked bovine pericardium confirms suitability for cardiovascular substitutes. APL Mater. 1 January 2024; 12 (1): 011104. https://doi.org/10.1063/5.0182672

Viewing the results back in OMERO



https://omero-guides.readthedocs.io/en/latest/parade/docs/omero_parade.html

FiJi/ImageJ



Feature	Support
Import images	✓
Batch Processing	✓
ROI import/export	✓
Export results	✓

Three main plugins for connecting to OMERO:

- **OMERO plugin for Fiji** https://omero-guides.readthedocs.io/en/latest/fiji/docs/index.html
- **OMERO Batch Plugin** https://github.com/GReD-Clermont/omero_batch-plugin
- **JIPipe** https://jipipe.hki-jena.de/

FiJi/ImageJ – OMERO analysis DEMO

The video is available on youtube at:

https://youtu.be/lRIOFpYYyCA?si=q3D-0bBhIXuoU3XQ

QuPath

Two main plugins for connecting to OMERO:

- **qupath-extension-omero**

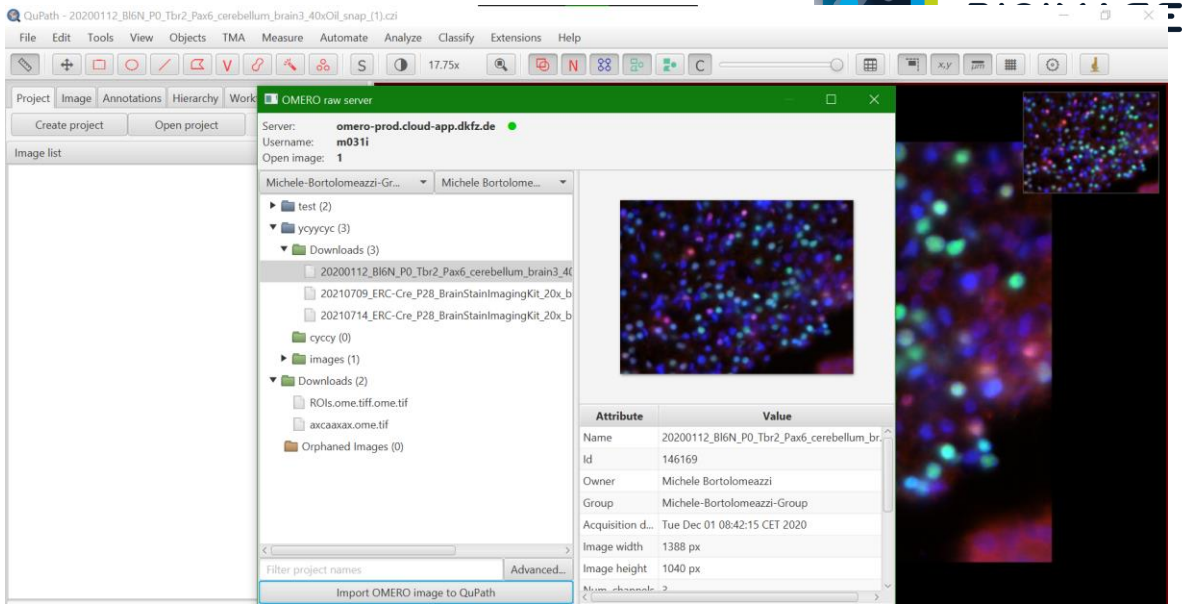
https://github.com/qupath/qupath-extension-omero

The images are retrieved as JPEG-compressed RGB which are suitable only for viewing and annotation.

- **qupath-extension-biop-omero**

https://github.com/BIOP/qupath-extension-biop-omero

Allows to retrieve the raw pixel data.



Feature	Support
Import images	✓
Batch Processing	✓
ROI import/export	✓
Export results	✓

Bankhead, P. et al. QuPath: Open source software for digital pathology image analysis. Scientific Reports (2017). https://doi.org/10.1038/s41598-017-17204-5

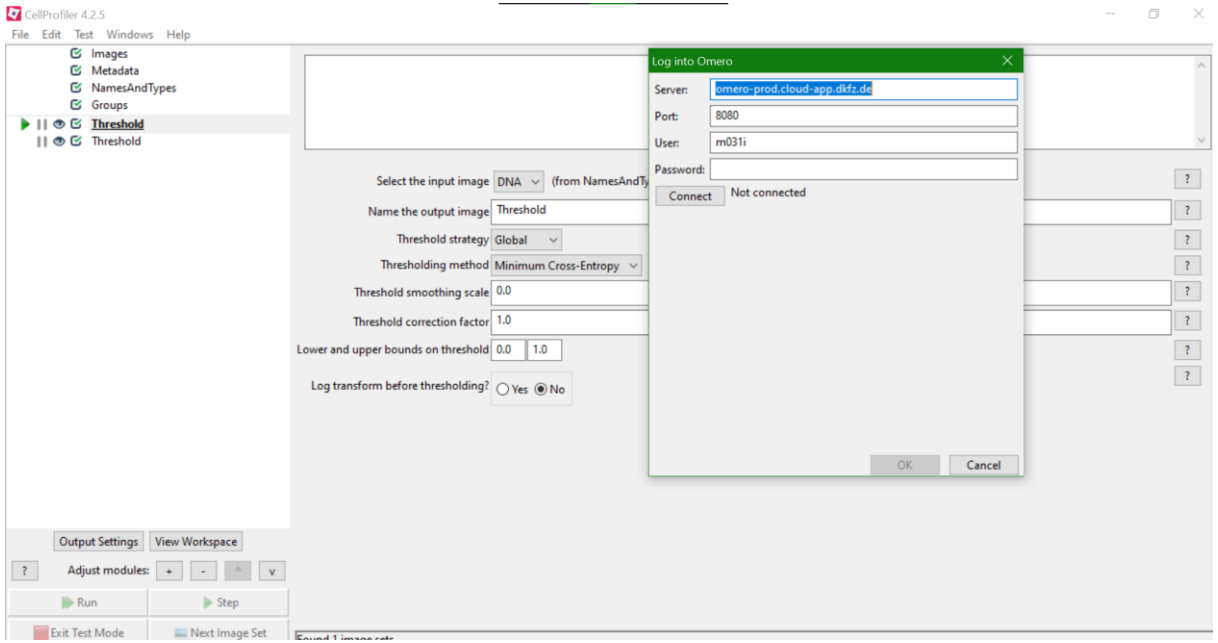
QuPath – OMERO analysis DEMO

The video is available on youtube at:

https://youtu.be/iOA0lWgOw-A?si=hpR1KY2DhadlAVcw

CellProfiler

Allows the user to concatenate operations into pipelines which can be easily shared and reproducible.



More complete workflows can be performed using the Cellprofiler and OMERO APIs in python.

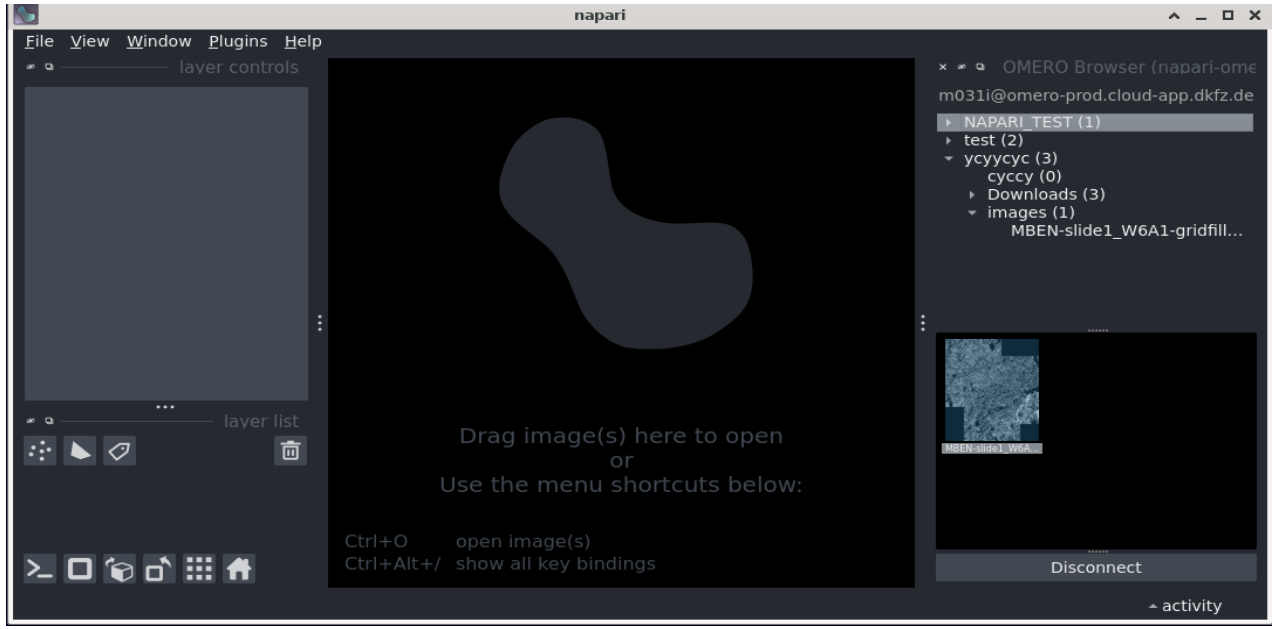
https://omero-guides.readthedocs.io/en/latest/cellprofiler/docs/cellprofiler.html

https://forum.image.sc/t/establish-connection-between-omero-cellprofiler/22438/10omero:iid=477553

Feature	Support
Import images	✓
Batch Processing	✓
ROI import/export	✗
Export results	✗

Napari

OMERO GUI interface for browsing an OMERO instance in napari and import images. The GUI has only limited functionality, and does not support switching groups.

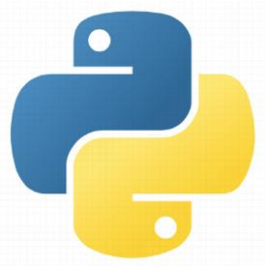


More functionalities are available through the python CLI interface in napari.

https://github.com/tlambert03/napari-omero

Feature	Support
Import images	✓
Batch Processing	✗
ROI import/export	✗
Export results	✗

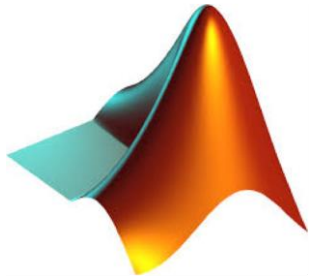
OMERO APIs



OMERO python API
ezOMERO

OMERO Java Gateway

rOMERO Gateway



OMERO.matlab toolbox

Easing OMERO adoption with ezomero. Erick Martins Ratamero, Kiya Govek, Julio Mateos Langerak, Fernando Cervantes Sanchez, David J. Mellert. bioRxiv 2023.06.29.546930; doi: https://doi.org/10.1101/2023.06.29.546930

Reproducible scripting with OMERO

- Version control and share the code (add a link to the repository to OMERO)
- Make the environment reproducible (containers, virtual environments)

Much easier to reproduce the workflow on another HPC system.

- Use workflow management for bulk processing:
  - Nextflow and NfCore (e.g. McMicro for highly multiplexed images)
  - Snakemake

https://www.openmicroscopy.org/omero/features/analyze/
https://omero-guides.readthedocs.io/en/latest/external_tools.html

What about ML workflows?

OMERO is great for annotating images (especially cooperativelly), store, and review annotations.

https://biapol.github.io/blog/johannes_mueller/yolo_from_omero/train_yolo.html#omero

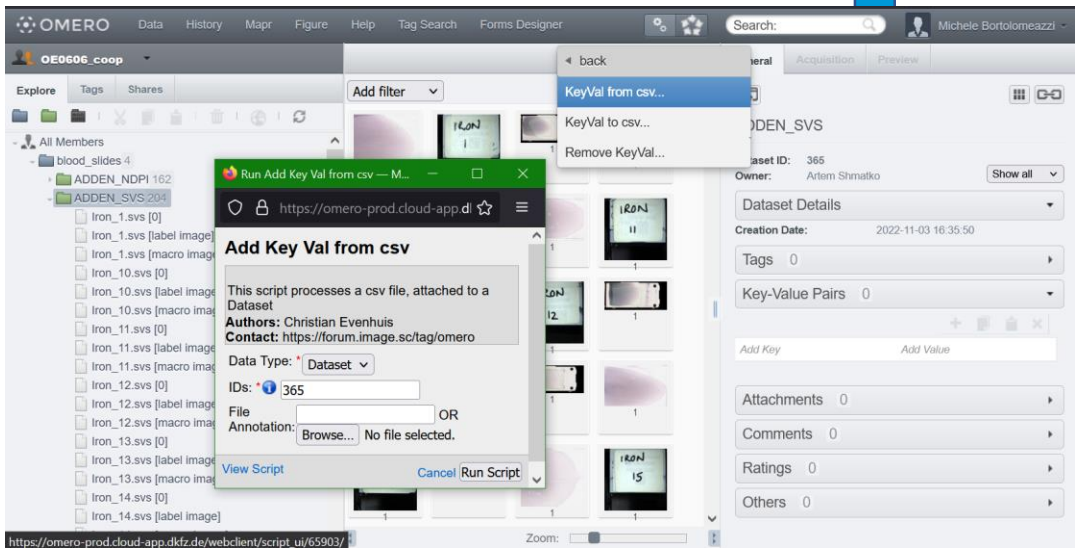
- Share the model:
  - BioImage Model Zoo:

- Or the whole pipeline:
  - DL4MicEverywhere
  - ZeroCostDL4Mic

BioImage Model Zoo: A Community-Driven Resource for Accessible Deep Learning in BioImage Analysis bioRxiv 2022.06.07.495102; doi: https://doi.org/10.1101/2022.06.07.495102

DL4MicEverywhere: deep learning for microscopy made flexible, shareable and reproducible. Nat Methods 2024 DOI: https://doi.org/10.1038/s41592-024-02295-6

OMERO.scripts



OMERO.scripts allows users to run pre-approved scripts on the server. Generally this is mostly used for annotations, but it can be used also for the analysis.

The scripts are run on the server:

- Need to be approved/uploaded by an admin
- Need to have enough computational resources

Python based natively, but MatLab is supported and other tools can be installed.

https://omero.readthedocs.io/en/stable/developers/scripts/advanced.html

https://omero.readthedocs.io/en/stable/developers/scripts/index.html

Conclusions

A large number of image analysis tools can be combined with OMERO for

- Storage for data and metadata under analysis.
- Cooperative annotations and sharing of images.

This enables users to:

→ develop, use, and share reproducible image analysis workflows.

→ more easily publish their data in public repositories.