The OMERO Platform

An open source solution for microscopy metadata management, visualization and analysis

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open microscopy environment

Abstract

The OMERO Platform aims to provide a complete solution for image data management. Both cross-platform and cross-language, OMERO provides highly-scalable remote access to your raw data and metadata from anywhere in the world, even over a wireless connection.

Recently, we have started adding in specific image processing and analysis functions, along with facilities for running your own self-scripted algorithms and transformations.

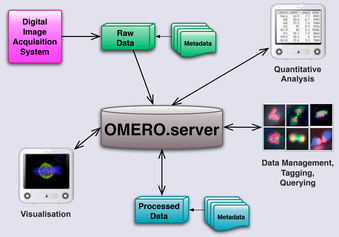
OMERO is an open source development project and we welcome input, advice, comments, and help. Go to http://www.openmicroscopy.org and see what we are up to!

google: OMERO http://www.openmicroscopy.org/

OMERO.server

OMERO.server combines enterprise database, search, scripting, security, and interface technologies and serves as the foundation of our image data management solution. Together these tools form a highly-scalable, cross-platform, cross-language service for remote users allowing them secure access to images and metadata from any internet connection.

In the latest release, support has also been added for sending self-scripted algorithms and transformations to where the data is stored rather than bringing the data to you, again making the most of your data and time.



OMERO.server also provides a simple to use Google-style search interface for quickly finding data in addition to a more complete SQL-like language for building reports and other data mining.

In addition, the server provides flexible security mechanisms similar to a Unix operating system, both in terms of users and groups as well as file and directory permissions.

Whatever your data dimensions – countless frames, high-resolution images, or extensive videos – OMERO.server provides mechanisms for managing your data and discovering new scientific insights.

Server Features

- **Hibernate Query Language** – All data in the server is queryable via HQL. Simpler than SQL, HQL provides powerful mining capabilities while freeing the developer from low-level details like security and individual field loading.
- **Stateful Services** – In addition to storing data in the database, the server can remember settings and given state over the course of multiple sessions.
- **Row-level Security** – Each entry in the database is protected by both a READ and WRITE flag for USER, GROUP, and OTHER.
- **Audit Trail** – All interactions with the server are recorded in "Events" which can be examined by the system administrator.
- **Database Versioning** – Each version of the OMERO database comes with all necessary upgrade scripts for safely moving your data from previous supported versions.

Support is also provided for:

- **Structured Annotations** – Attach your own data to objects in OMERO
- **Scripting** – Tools for running custom analysis and integration with CellProfiler

google: OMERO.server http://www.openmicroscopy.org/info/OMERO.server

OMERO.importer

OMERO.importer is a desktop tool for importing over 30 different file formats into our centralized OMERO server. Designed as *a fire and forget* application, it is ideally suited for importing your images in the background, while you work, or operating after hours while your computer sits idle. The importer's *import queue* enables you to browse and select files for import, organize them into projects and datasets, provide brief annotations, and organize them before import. Images can also be archived alongside the import process, allowing you to retrieve your untouched image files from the OMERO.server at a later date, and the client's history feature allows you to search and review your previous import sessions and then re-import your images if desired.

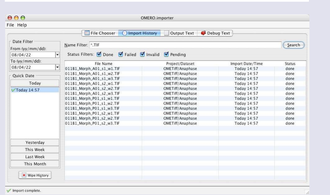
Written using Sun Microsystems' Java language, OMERO.importer is cross-platform compatible with all major operating systems, easy to set up, and simple to understand. It is built on recognized and robust technologies and makes use of the Bio-Formats imaging package.

Benefits For Users:

- **Easy to set up** – one download provides you with a working importer on any platform compatible with Java 1.5.
- **Cross-platform** – ideally suited for real world environments with multiple operating systems and system specs.
- **Fire & forget operation** – the importer's queue function lets you set up your import and then continue with your day.
- **Robust file format support** – over thirty different formats supported and still growing!

Benefits For System Administration:

- Based on robust, open-source tools.
- Ease of operation and cross-platform nature means less training and technical support issues.
- Ideal for use "at the work station" – where image data is collected.



google: OMERO.importer http://www.openmicroscopy.org/info/OMERO.importer

OMERO.insight

OMERO.insight is a desktop tool for accessing, manipulating, collaborating, viewing and performing basic measurement on data stored in an installation of OMERO.server.

Data Management

- In the left-hand pane is a traditional tree-based view of the data hierarchies in your OMERO.server.
- In the middle pane is a working area used to select and filter data to work on.
- In the right-hand pane is a tool to work on the selection i.e. rate, tag, annotate, etc.

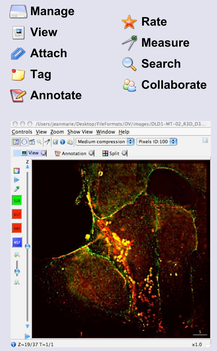
Viewing

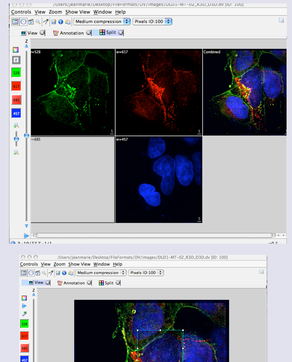
- Allows visualization of 5D images (space, channel, time).
- Makes use of the OMERO.server's Rendering Engine.
- Provides high-performance viewing of multidimensional images on standard workstations, without requiring installation of high-powered graphics cards.

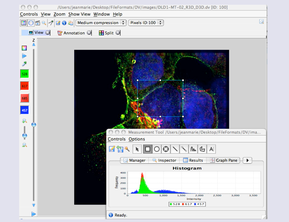
Measurement

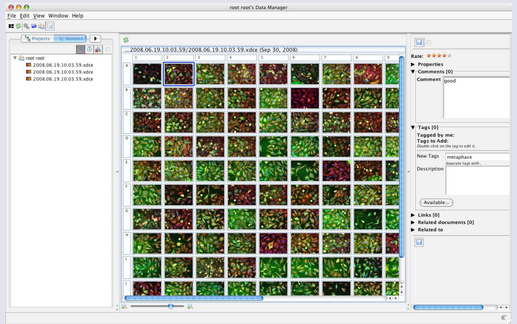
- Draw Regions Of Interest (ROI) on the image: Squares, Ellipses, Polygons, Lines.
- Creates ROIs across Time and Z-sections.
- Measures the geometry and intensity values of the pixels under the ROI.
- Views histogram of the intensity values under the ROI.
- Exports all results to a spreadsheet.

Display of Plates of HCS data, shown below, is currently in testing and we hope to include it in the next major release.









Written using Sun Microsystems' Java language, OMERO.insight is cross-platform compatible with all major operating systems, easy to set up, and simple to understand. It is built on recognized and robust technologies such as JHotdraw, a drawing library and the JBoss transactional framework. It was built in collaboration with OME's design ethnography team Usable Image.

Benefits For Users:

- **Easy to set up** – one download provides you with a working importer on any platform compatible with Java 1.5.
- **Cross-platform** – ideally suited for real world environments with multiple operating systems and system specs.
- **Remote access** – manipulate, view data without sitting at the workstations e.g. from your office, in the lab, or your favourite internet cafe.

Benefits For System Administration:

- Based on robust, open-source tools.
- Ease of operation and cross-platform nature means less training and technical support issues.

google: OMERO.insight http://www.openmicroscopy.org/info/OMERO.insight

LOCI Bio-Formats

Bio-Formats is a standalone Java library for reading and writing microscopy file formats. It is capable of parsing both pixels and metadata for a large number of formats, as well as writing to several formats.

Bio-Formats's primary purpose is to convert proprietary microscopy data into the OME data model, an open standard. This may be stored as either OME-XML or the more space efficient OME-TIFF file format. The Bio-Formats manifesto provides a thorough explanation and rationale of the directions taken while creating this library.

Benefits For Users:

There are several software packages that can use Bio-Formats to read and write microscopy formats. These include ImageJ, VisBio, OME, VisAD, Endrov and MATLAB.

Benefits For Application Developers:

Bio-Formats provides a library to support working with a large number of formats in there own software. The Bio-Formats library provides a common interface to the developer regardless of file format. As the library is improved and new formats added the developer can take advantage of these improvements with little effort.

Bio-Formats is open source software licensed under the GNU General Public License.

#	Format	Extensions	Pixels	Metadata	Physical Presence	Utility
1.	Adobe Photoshop PSD	.psd	✓	✓	✗	✓
2.	Alicona 3D	.al3d	✓	✓	✗	✓
3.	Amersham Biosciences GEL	.gel	✓	✓	✗	✗
4.	Andor Bio-Imaging Division (ABD) TIFF	.tif	✓	✓	✗	✗
5.	Animated PNG	.png	✓	✓	✓	✗
6.	Aperio SVS TIFF	.svs	✓	✓	✗	✓
7.	AVI (Audio Video Interleave)	.avi	✓	✓	✗	✗
8.	Becker & Hickl SPCImage	.sdt	✓	✓	✗	✗
9.	Bio-Rad PIC	.pic	★	✓	✗	✗
10.	Bitplane Imaris	.ims	✓	✓	✗	✗
11.	BMP (Windows Bitmap)	.bmp	✓	✓	✗	✗
12.	DeltaVision	.dv, .r3d	★	✓	✓	✓
13.	DICOM	.dcm, .dicom	✓	✓	✓	✗
14.	EPS (Encapsulated PostScript)	.eps	✓	✓	✗	✗
15.	Evotec Flex	.flex	✓	✗	✗	✗
16.	FEI	.img	▬	✓	✗	✗
17.	FITS (Flexible Image Transport System)	.fits	✓	✓	✓	✗
18.	Gatan Digital Micrograph	.dm3	✓	✓	✗	✗
19.	GIF (Graphics Interchange Format)	.gif	✓	✓	★	✗
20.	Hamamatsu Aquacosmos NAF	.naf	✓	✓	✗	✗
21.	ICS (Image Cytometry Standard)	.ics	✓	✓	✓	✗
22.	ImagePro Sequence	.seq	▬	✓	✗	✗
23.	ImagePro Workspace	.ipw	✓	✓	✗	✗
24.	Improvision Openlab LIFF	.liff	✓	✓	✗	✗
25.	Improvision Openlab Raw	.raw	★	✓	✗	✗
26.	Improvision TIFF	.tif	★	✓	✓	✓
27.	InCell 1000	.xdce, .tif	✓	✓	✓	✓
28.	IPLab	.ipl	★	✓	✗	✗
29.	JPEG	.jpg	✓	✓	★	✗
30.	JPEG 2000	.jp2	✓	✓	✗	✗
31.	Khoros VIFF (Visualization Image File Format) Bitmap	.xv	✓	✓	✗	✗
32.	Leica LAS AF LIF (Leica Image File Format)	.lif	✓	✓	✗	✗
33.	Leica LCS LEI	.lei, .tif	✓	✓	✗	✗
34.	Li-Cor L2D	.l2d, .tif, .scn	✓	✓	✗	✗
35.	LIM (Laboratory Imaging/Nikon)	.lim	✓	✓	✗	✗
36.	MetaMorph7.5 TIFF	.stk	✓	✓	✗	✗
37.	MetaMorphStack (STK)	.stk	✓	✓	✓	✗
38.	µManager	.tif, .txt	✓	✓	✓	✗
39.	MINC MRI	.mnc	✓	✓	✓	✗
40.	MNG (Multiple-image Network Graphics)	.mng	✓	✓	✓	✗
41.	MRC (Medical Research Council)	.mrc	★	✓	✓	✗
42.	NEF (Nikon Electronic Format)	.nef, .tif	✓	✓	✗	✗
43.	Nikon NIS-Elements ND2	.nd2	✓	✓	✗	✗
44.	nrrd (Nearly Raw Raster Data)	.nrrd	✓	✓	✓	✗
45.	Olympus Ji SlideBook	.sld	✓	✓	✗	✗
46.	Olympus Cell®/APL	.apl, .mtb, .tnb, .tif	✓	✓	✗	✗
47.	Olympus FluoView FV1000	.oib, .oif	✓	✓	✗	✗
48.	Olympus FluoView TIFF	.tif	✓	✓	✗	✗
49.	OME-TIFF	.ome.tif	★	✓	✗	✗
50.	OME-XML	.ome	▬	✓	✗	✗
51.	PerkinElmer UltraView	.tif, .2, .3, .4, ...	✓	✓	✗	✗
52.	PICT (Macintosh Picture)	.pict	✓	✓	✗	✗
53.	PGM (Portable Gray Map)	.pgm	✓	✓	✗	✗
54.	PNG (Portable Network Graphics)	.png	✓	✓	✓	✗
55.	Prairie Technologies TIFF	.tif, .xml	✓	✓	✓	✗
56.	QuickTime Movie	.mov	✓	✓	✗	✗
57.	SimplePCI	.cxd	★	✓	✗	✗
58.	TIFF (Tagged Image File Format)	.tif	✓	✓	✓	✗
59.	VisiTech XYS	.xys, .html	✓	✓	✓	✗
60.	Zeiss AxioVision ZVI (Zeiss Vision Image)	.zvi	✓	✓	✗	✗
61.	Zeiss LSM (Laser Scanning Microscope) 510	.lsm	✓	✓	✓	✗

google: Bio-Formats http://www.loci.wisc.edu/ome/

OME Data Model

The OME Data Model was devised to allow the interchange of microscope data. It is an open standard providing a rich description of image metadata.

Information contained within the model can include:

- Information about the Experiment itself
  - Who is conducting the work
  - What group the work is for
- A project and dataset structure to organize data
- Detailed instrument and light path information
  - Light sources
  - Filters
  - Dichroic Mirrors
  - Objectives
  - Detectors
  - Any associated OTF (optical transfer function)
- A powerful image object to work with representing
  - The environment of the sample
  - How the sample is being manipulated
  - An unlimited number of channels
  - Stage position on a per plane basis for tiling
  - A 5-D structure (X, Y, Z, Channel and Time)
- A Screening model that supports multiple screens, plates, wells and images with their associated reagents.

The data model is provided as an XML Schema. This allows the creation of XML files to hold your data. This is the OME-XML format that has the raw pixel data directly encode into the XML.

We also provide a method of combining the OME Data Model with that imaging staple, the TIFF file. The OME-TIFF format allows the metadata to be represented as an XML block within the header of a TIFF file containing the raw pixel data. This has been further extended to provide multi-file support.

As an extension to the data model we also provide formats for Semantic Type Definitions and Structured Annotations. These provide the user with support to add their own types and data directly into the files in a format that our servers can interpret.

OME Screen Plate Well

The model has flexible support for modelling the concepts used in high content screening. Full information about these models is available online.

google: OME-XML http://www.ome-xml.org/

OMERO.web

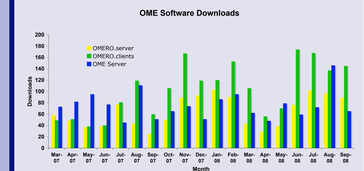
OMERO.web client is a rich internet application that allows for the management, viewing, attachment, and association of files to images, datasets, and projects. This includes a fully multidimensional image viewer running inside your web browser. Searching and tagging of information are available to further organise and manage data.

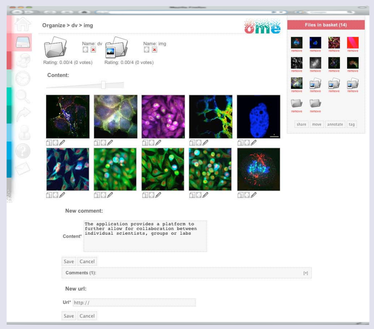
The application provides a platform to further allow for collaboration between individual scientists, groups or labs and a pathway for publishing work. It is specifically designed as a "thin" client, for remote access.

OMERO.web uses Django, a high-level Python web framework, jQuery, a new JavaScript library and Ajax interaction technology, to communicate with OMERO.server. It is a web application, that has the features and functionality of traditional desktop applications and transfers the processing necessary for the user interface to the web client but keeps the bulk of the intensive data processing back on the application server.

For users the key benefits are:

- **No Installation Required** – The client runs through the web browser so delivery of the application is instant, and can be used from any computer with an internet connection.

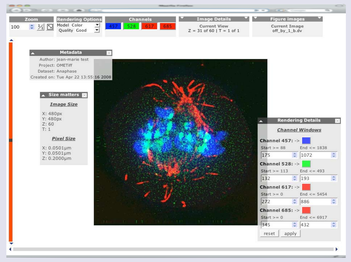




- **Instant Updates & Upgrades** – New versions are automatically available independent of operating system.
- **Rich set of functions** – Including Drag and Drop data management, and a fully functional 5-Dimensional data viewer.

For system administration the key benefits are:

- The demand for client and server computing resources is better balanced, allowing the same server hardware to handle more client sessions concurrently.
- The client engine can interact with the server without waiting for the user to perform an interface action. This allows the user to view and interact with the page asynchronously from the client engine's communication with the server. This option allows RIA designers to move data between the client and the server without making the user wait.
- The network traffic may also be significantly reduced because an application-specific client engine is more intelligent when deciding what data needs to be exchanged with servers.

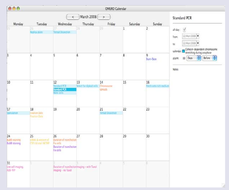


google: OMERO.web http://www.openmicroscopy.org/info/OMERO.web

OMERO.editor

OMERO.editor is an editing tool for scientists to record and manage their experimental metadata. This tool is a stand-alone cross-platform application that saves files as XML documents. OMERO.insight can attach these files to images and can also open OMERO.editor files attached to images.

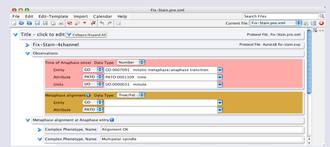
Experimental metadata is represented within OMERO.editor in the form of fields, which can be arranged hierarchically. A number of fields can be used to describe a protocol or data model, by editing the field name and adding a description to each field. In addition, a field may be used to record an experimental variable, or frequently changing parameter, such as a name, number or date.

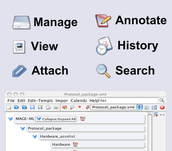


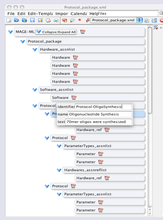
OMERO.editor makes it easier to describe the data associated with an experiment and then capture it in a structured and reusable form.

OMERO.editor key features

- Easier re-use of protocols by separating out the experimental variables.
- Import multiple small protocols (e.g. siRNAi treatment, Fix-stain) into a larger protocol, to describe a complete experiment.
- Use Date-Time fields to schedule future experiments, and set pop-up reminders.
- Future and past protocols can be browsed via Date-Time using the calendar.
- Search your OMERO.editor files using either a *Key-Word* search or *More-Like-This* search to find files similar to the currently viewed file.
- Lock chosen fields to prevent editing, or lock only the protocol template to allow editing of experimental variables.







google: OMERO.editor http://www.openmicroscopy.org/info/OMERO.editor

The Open Microscopy Environment is a multi-site collaborative effort among academic labs and a number of commercial entities that produces open tools to support data management for biological light microscopy. Our goal is to provide life scientists with open source access to sophisticated tools to support their work. Designed to interact with existing commercial software, all OME formats and software are free, and all OME source code is available under GNU public "copyleft" licenses.

OME is developed as a joint project between research-active labs at the Dundee, NIA Baltimore, Harvard and LOCI. In addition, OME has active collaborations with many imaging and informatics groups.

We would like to thank the following organisations for there contributions to the OME development effort:

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Improvision Inc.
Intelligent Imaging Innovations, Inc.
Leica Inc.
Nikon Inc.
OPIA
Olympus America, Inc.
Omega Optical Inc.
PerkinElmer Life and Analytical Sciences Inc.
SVision, LLC
Scientific Volume Imaging
Universal Imaging Corp.
Vanderbilt University School of Medicine