

User guide Cytomine version 1.0 (Version: 20160116)

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This document covers the main functionalities of our software. The software can be tested at <u>http://demo.cytomine.be/</u> with one of these 3 accounts, using a modern web browsers (Google Chrome (preferred choice), Safari, Mozilla Firefox):

Username	Password	Role
jsnow	jsnow	User
clannister	clannister	User
estark	estark	User

The software can also be installed automatically on desktop/server computers using the procedure described in Section 6.1. In both cases, our installation procedure installs "toy data", namely five projects for testing main functionalities.

6.1 Installation

The automated installation procedure is described at: <u>http://doc.cytomine.be/x/goCj</u>

It basically requires the edition of a single configuration file (Bootstrap/configuration.sh) and the execution of a few command lines. The procedure will automatically create virtual environments (using Docker deployment system) for each Cytomine components and download, compile, and install all the required libraries, and start all servers. The whole process takes approximately 2 hours without user intervention. The web user interface is then directly accessible at the http:// \$CORE_URL\$ location (e.g. http://demo.cytomine.be) using modern web browsers (we recommend using Google Chrome).

6.2 Usage (Cytomine-WebUI)

This guide explains how to:

- Visualize and annotate manually images
- Configure projects and manage users
- Upload new images
- Apply Cytomine-DataMining analysis modules and proofread them
- Perform textual search
- Follow online users
- Blind assessment (including IRIS: the Inter-observer study module)

In this guide, we assume using the "jsnow" account.

Please refer to your web browser documentation for basic navigation operations (e.g. "F5" key might be useful to reload pages).

<u>6.2.1 Visualization and manual annotations</u> Users log into Cytomine using the login panel:

Sign in to Cytomine	
jsnow	
🗹 Remember me	Sign in
Forgot your username or your password	?





Once connected, the user has access to its user dashboard which summarizes global information (number of projects, images, annotations) and it also shows latest opened projects, images, and activities:

Cytomine ODashboard E Projects	🕏 Explore 🛛 🗮 Storage 🛛 & Activity				Ø About Us → LSnow Jon (jsnow) →	
	This is a Cytomine dem guarantee when using avoid that). If you are in	It in the future the amount of data per user. Also, we d imply potential unavailability and data loss (altough w cytomine.be) for a collaboration.	o not provide any will do our beet to			
SHORTCUTS »		Go to project >				
STATISTICS »	20 PROJECTS Now	165 IMAGES Now	293 ANNOTATIONS Now	0 REVIEWED Now	PROJECTS »	
LAST OPENED IMAGES »	MULLER-LAB-ZEBR 2015-08-11 14h57	Euroz.JP2 2015-06-11 14004	LUNGT.JP2 2015-06-11 14004	05-2.NDPI 2015-06-11 11/166	CELLS7.PNG 2015-06-11 11/14	
LAST OPENED PROJECTS »	_DEMO-LANDMARK-ZEBRAFISH- TEST 2015-06-11 14h57	_DEMO-SEGMENTATION-TISSUE 2015-08-11 14047	_DEMO-VARIOUS 2015-06-11 14042	_DEMO-CLASSIFICATION-CELL 2015-06-11 14h20	TESTSCRIPTTEST-TUMOR- DETECT123 2015-06-11 14h04	
YOUR ACTIVITY »	No Datr	a Available.	2015-06-11 14h04: Property @CUSTOM_UU_PROJECT edited for be cytomine project.Project 277,246 2015-06-11 14h04: Property @CUSTOM_UU_PROJECT edited for be cytomine project.Project 277,246 2015-06-11 14h04: Property @CUSTOM_UU_PROJECT edited be cytomine project.Project 277,246 2015-06-11 13h04: Jon Brows edided an annotation 038,646 2015-06-11 13h04: Jon Brows edided an annotation 038,646 2015-06-11 13h04: Jon Brows edided an annotation 038,646 2015-06-11 13h04: Jon Brows edided an annotation 038,649 2015-06-11 13h04: Jon Brows edided an annotation montation 038,649 2015-06-11 13h04: Jon Brows edided annotation montation 038,649 2015-06-11 13h04: Jon Brows edided annotation montation 038,649 2015-06-11 13h04: Jon Brows edided annotation 038,649 2015-06-11 13h04: Jon Brows edided annotation 038,649 2015-06-11 13h04: Jon Brows edided annotation 038,649 2015-06-11 13h04: Jon Brows added and annotation 038,649 2015-06-11 1			

The menu on the top right (black bar) gives access to Account information (under the user name) where the user can change its password and get its public/private keys. The help sub-menu lists main shortcuts applicable when exploring images:

3 About Us -	LSnow Jon (jsnow) √
Help	L Account
I Support	也 Logout
About Cytomine	

The menu on the top left (black bar) gives access to the User dashboard, the listing of Projects, the Storage panel (to upload new images through the web interface), and the Activity panel which summarizes latest user activities:

Cytomine 🎯 Dashboard 🗐 Projects 👁 Explore 💻 Storage 🍌 Activit	ty
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The project listing displays boxes where each box corresponds to a specific project. Project listing can be filtered (box at the top left) by names, number of annotations, images, disciplines, ontology names:





Clicking on the project name (e.g. _DEMO_SEGMENATION_TISSUE) or on the Open button will open the project and shows the Project dashboard with basic information (textual description on the top right, users currently online) and various statistics about the project (including number of images, annotations, various statistics of annotations by ontology terms, users, images, ...).

_DEMO-SEGMENTATION-TISSUE	Images	Annotations Properties	Configuration				
		DEMO-SEGMENT	ATION-TISSUE				
		Ontology User annotations Job annotations Reviewed annotations See users Lock project & ONLINE USERS	_DEMO-SEGMENTATION-TISS 20 0 0	UE-ONTOLOGY	Description This projects contains wit laboratory (<i>Laboratory</i> o See full text and edit	role-silde histology (H&E) images o গf Tumor & Development Biology	f mouse lungs provided by Didler Cataldo's , GIGA-Cancer, University of Liège).
		Snow Jon (jsnow) ACTIVITY Last commands Last 11/8/2015 11:42:58 : Image LUNG2 jp2 added - 11/8/2015 11:42:37 : Jon Snow added an anno - 11/8/2015 11:42:37 : Tem - 11/8/2015 11:42:37 : Tem - 11/8/2015 11:42:37 : Tem	t tasks in project _DEMO-SEGMENTATK I Tumor is added to annotation 277 tation in LUNG1.jp2 by jsnow 1 Tumor is added to annotation 276	DN-TISSUE by jsnow 3,747 by jsnow 3,734 by jsnow			ĺ
		Jon Snow added an anno - 11/6/2015 11:42:37 : Term 14/6/2015 11:42:37 : I ANNOTATIONS V	n Tumor is added to annotation 276 S TERM	9,721 by jsnow			
	.li an	NOTATIONS VS TERM					●Tumor ● Negative
	10	0	0.00			10.00	
	0	0 	¢	0.00 Se ^{ren}		and the second se	
	di AN	NOTATIONS BY USER					
	10 5	0		10.00		10.00	
	0	C. C	3.00 }⊁	Les States		Construction	
	JI AN	NOTATED SLIDES BY TERM	1				
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	0	,	ą	a spech		0.00	

One key concept of Cytomine is the Ontology, a structured vocabulary of user-specified terms used for the semantic annotation of regions of interest in images. Each project has a single ontology. It can be either an existing ontology (it can be associated with the project when a user creates it) or a new ontology that can be edited online. Editing the ontology can be done by clicking on its name (first line under the project name) which opens the Ontology editor. The editor allows to rename the ontology, add/edit/delete terms from the ontology. In this "toy" project where life scientists are interested to quantify the sizes of tumor islets with respect to the size of tissue sections, the Ontology is simplified and has only three terms: Section (to delimit the tissue section, in brown), Tumor (for tumoral islets, in red), and Negative (for all other tissue substructures, in green):

Ontologies + Add C Refresh	_DEMO-SEGMENTATION-TISSUE-ONTOLOGY	
DEMO-EMPTY DEMO-LANDMARK-ONTOLOGY DEMO-VARIOUS TESTSCRIPTDEMO-CELLS123 TESTSCRIPTEMPTV123 TESTSCRIPTEST-TUMOR-DETECT123 TESTSCRIPTZEBRA-DEMO-TRAINING123 DEMO-CELLS DEMO-CANDMARK-ONTOLOGY DEMO-LANDMARK-ONTOLOGY DEMO-LANDMARK-ONTOLOGY DEMO-LANDMARK-ONTOLOGY DEMO-VARIOUS DEMO-LANDMARK-ONTOLOGY DEMO-VARIOUS DEMO-VARIOUS DEMO-VARIOUS nuIDEMO-CELLS1 nuIDEMO-CELLS123	Ontology : D Add ISSUE-ONTOLOGY Creator: Shared with : Projects : DE Delete SSUE Nogative Socian Tumor ,	
Name Tumor Ol color # 10000 New Color # 1	Parent (Drag & Drop) DEMO-SEGMENTATION-TISSUE-ONTOLOGY Negative Socion Tumor Basic Colors Saved Colors Advanced white red green green blue	
		Save



the ontology is defined, one can start semantically annotating whole-slide images. It has to be noted that Term names and colors can be changed afterwards, only term identifiers are linked to annotations in the database. To start annotation, the user goes back to the Project dashboard and clicks on the "Images" tab which opens a page with the Image listing of this project:

_DEMO-SEGMENTATION-TISSUE					In	nages	Annotations		F	Properties		Configuration		
Cytomine	😋 Dashboa	ard 🗐 Projects 👁 Explore	Storage	√ 9 Activity									<table-cell> About U</table-cell>	Js≁ LSnow Jon (jsnow) ≁
_DEMO-SEG	MENTATION-1	TISSUE Images Annotat	ions Properties	s Configuration										
							+ Add new image 🛛 🎗	Refresh						
	10			 records 	per page			5	Search:					
	ID .	Preview	Name	Width (px)	Height (px)	Magnitude	Resolution (µm/pixe)	User an, 🍐	Algo an.	Valid an.	Vendor	Created	Status	Action
	278814	-	LUNG2.jp2	38912	32256	Undefined	Undefined	0	0	0	Undefined	2015-06-11 11h42	None	Explore -
	278476	\$ 4	LUNG1.jp2	30720	25600	Undefined	Undefined	20	0	0	Undefined	2015-08-11 11h42	None	Explore
	Showing 1 to	2 of 2 entries											144	< 1 > ₩

This project contains only 2 images whose characteristics are listed. Image "LUNG1.jp2" already contains 20 user annotations. One can open the image by clicking on its thumbnail or on the blue Explore button at the right. Note that the arrow at the right of the Explore button gives access to supplementary information and operations (e.g. download the image, describe it, start reviewing it (see below), importing annotations from another project, ...). The explore view is then displayed. It is a zoomable viewer for gigapixel images, with various tools for annotation. Note that multiple images can be opened in parallel, each one having its own tab. By default (this can be configured in the "Configuration" tab of the project), the viewer also displays current user's annotations (in red



Annotations can be selected **\$\$Select**, edited, and drawn manually by using tools on the top bar:

Select OPoint Arrow Rectangle Ellipse Circle Polygon MagicWand 🖍 🕂 - Kill Ruler Edit Rotate Resize Drag 🏛 🔄

It includes geometries such as:

• Point, Rectangle, Ellipse, Circle, Polygon,

here, corresponding to the color of the Tumor term):



• Freehand 🖍

• Magic Wand (which parameters have to be configured in Project Configuration tab) And operations such as:

- Rotate, Resize, Drag,
- Delete 🗖
- Fill
- Complement (performs the union of a new geometry with an intersecting, existing, geometry) +
- Subtract (subtracts the intersection of a new geometry with existing geometry)

Selecting an annotation opens the Current Selection Annotation panel (at the bottom left) which gives basic information (e.g. annotation area based on image resolution) about the currently selected annotation and launch the content-based image retrieval algorithm. This algorithm suggests ontology terms based on visual similarity. The most similar annotations can be visualized by clicking on "See Similar Annotations" (they are ranked according to their computed similarity):





It is possible to click on these "similar" annotations to jump directly at their locations within their original image.



Properties (key-value pairs) and keywords can be added to Annotations by clicking on the "Add property" link (at the bottom of the Current Selection panel).

Annotation Image Project 278545 - 2015-06-11 11h42 ▼	Add a property	
Refresh List	Key CellCount Value 9380987403987	Add Property
	Add a keyword	
AL SO	Properties Key Value	Delete
	Info: To edit a property, double-click on the key or the value.	. Valid with Enter.
	No data to display	
	Delete Property	

Rich text descriptions can also be added in a similar way as for Projects and Images.

On the right side of the Explore view, the "Tools" panel can be activated to show an overview (thumbnail with red square corresponding to the active view), image information, image layers (which allow to apply on the fly image processing filter to tiles, see Configuration page of the project), annotation layers (containing user layers, userjob layers, and the review layer), ontology, and multi-dimensional browser.



Selecting and adding another user layer will display its layer of annotations in the whole-slide images in addition to current user annotations (in this case, the user clannister only created annotations with the Negative term, in green):





Multiple user annotations can then be displayed. A blinded mode allows to hide other user layers if needed (see Project Configuration page).

Adding an annotation requires the user to draw it, then eventually associate a term from the Ontology (the color of the Annotation thus changes):



All annotations created in a project are visible in filtered galleries in the Project Annotations tab:

_DEMO-SEGMENTATION-TISSUE	Images	Annotations	Properties	Configuration	LUNG1.jp2	-
-	0			•		

Annotations can be filtered according to images they come from, terms from the Ontology, Users from the project and types (user/job/reviewed). Filters can be saved and reused later. The user can click on any of these annotations to jump to its actual location in whole slide images.

Annotation descriptions can be exported as tabular files containing annotation information (area, user who created them, direct link to it,...):



Cytomine O Dashboard II Projects O Explore	🎝 Activity	LSnow Jon (jsnow) ◄
_DEMO-SEGMENTATION-TISSUE Images Annotations Propertie	as Configuration LUNG1.jp2 -	
Filters Generic Is userfage annotations Basech Is mediations	Predefined Filters	
DEMO-SEGMENTATION-TISSUE Criteck all Undireck all	Undefined	
Annotations without terms Annotations with several terms	Multiple	
DEMO-SEGMENTATION-TISSUE-ONTOLOGY OFSTORE Official Control of Co		
Users Users Lunnistor Carsol (clannistor) Grow Joo (grow) Grok Eddard (clann)		
Creek all Undeck at	Section	
Odegmeniation_Model_Builder AutoLoungen_Model_Builder TitausDetect Stegmeniation_Model_Predict Titausdegment_Model_Predict	Tunor	
(Merior Burdellions) (Context Soldiard)	Download Overslaad CoNT Deverslaad Food Deverslaad FOOF	

	A	В	C	D	F	F	6	н	I	1	к
1	ld	Area (microns²)	Perimeter (mm)	x	Y	Image Id	Image Filename	User	Term	View annotation picture	View annotation on image
2	302661	554624.0	2958.0	7046.116321532636	4725.001467744019	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/302661/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-302661
3	278747	175230.0	1594.0	7069.32970381784	6572.665609009112	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278747/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278747
4	278734	227312.0	1880.0	5960.75249290256	6380.173060228526	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278734/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278734
5	278721	253480.0	1946.0	12556.091504918204	13743.268818052706	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278721/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278721
6	278708	251696.0	1973.0	9331.685970376962	19742.053609645496	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278708/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278708
7	278695	1704960.0	5357.0	11001.564964964966	12278.455655655656	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278695/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278695
8	278682	71540.0	1605.0	10794.882024042494	20723.60314975305	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278682/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278682
9	278669	162990.0	1568.0	8824.732830234983	19137.8159396282	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278669/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278669
10	278656	434896.0	4195.0	4590.964963270912	5427.768220448107	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278656/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278656
11	278643	129030.0	1419.0	10797.548818104317	13221.16981580511	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278643/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278643
12	278630	373352.0	2724.0	10976.037383845094	13842.707636046769	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278630/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278630
13	278617	14602.0	527.0	21993.5566817331	14925.346299593662	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278617/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278617
14	278604	117600.0	1372.0	20585.0	13798.0	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278604/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278604
15	278591	681792.0	3304.0	20730.0	17282.0	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278591/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278591
16	278578	443232.0	2664.0	25496.0	18924.0	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278578/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278578
17	278564	266760.0	2068.0	23736.0	14159.0	278476	LUNG1.jp2	clannister	Negative	http://demo.cytomine.be/api/annotation/278564/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278564
18	278545	1.6290496E7	18271.0	25481.181634248584	9723.086243496413	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278545/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278545
19	278532	279788.0	1982.0	26318.944643801737	15324.092674930067	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278532/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278532
20	278519	96759.0	1279.0	22222.987084750086	13198.883933277524	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278519/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278519
21	278506	57715.0	942.0	28014.469363828004	15463.157382540645	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278506/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278506
22	278492	76746.0	1585.0	22618.569549137515	10065.900478421101	278476	LUNG1.jp2	isnow	Tumor	http://demo.cytomine.be/api/annotation/278492/crop.png	http://demo.cytomine.be/#tabs-image-278366-278476-278492

In addition to ontology terms, properties, keywords, and rich text descriptions, Comments can be associated to Annotations and send through e-mail to project's users (using e-mail addresses encoded in the User account). E-mails contain the textual comment and a direct link to the actual location of the annotation within its gigapixel image for direct visualization. The user has to click on the blue "Comment" button in the Current selection panel, then select recipients and then click on the green "Share" button:

Comment/Share	an	annotation
---------------	----	------------

CURRENT SELECTION + Area : 554624 pixels ²		Comments
Perimeter : 2958 pixels	Share with	
✓ You can edit this annotation	Everyone	
Comment (0)	Email	
	Some users	
	Lannister Cersei (clannister) 🜸	
	Your comment	
	What do you think ?	
622		
Project		
_		
		Cancel Share

cytomine

configuration and user managment

Each project can be configured through the Configuration page:

_DEMO-SEGMENTATION-TISSUE Images Annotations Properties Configuration

Admins of a project can configure all options including general configuration (e.g. blind mode which hides image names, enable/disable the content-based image retrieval algorithm,...), user management (add/delete users from this project), configure the default annotation layer in the Explore view, customize the user interface to enable/disable graphical tools and displayed information (such as the drawing tools and panels), the image filters (that can be applied on-the-fly to image tiles), the softwares to be associated (e.g. the Cytomine-DataMining modules or any other third-party softwares registered to the database), and some other visual configuration (e.g. the magic wand tolerance parameter or the size of Point annotations, configurable by a regular User).

Configurations	
 General Configuration Users Management Default Layers Configuration Custom UI Configuration Image filters Softwares Private Annotation Tools Configuration 	

An existing user in the database can be added to the Project by an admin.

Users Management								
Project users:								
	Add users by name							
	Lannister Cennei (clannister) 🙁 Snow Jon (jsnow) 🔹 Stark Eddard (estark) 🙁 marce							
	Marée Raphaèl (maree)							
Project admins:	◎ Invite a new user							
A project admi	A project admin can edit/delete annotations from all users in the new project							
Snow Jon (jsnov	• ·							

To add new user into the database through the web user interface, admins or super admins have to enter into the Cytomine admin area where the can add new user or edit existing ones (including their role):



			L Account								
			A Open admin s	ssion							
			() Logout								
			₽								
Cytomine	🕑 Das	ashboard 🔳 Projects 🗐 🤇	Ontologies 👁 Exp	lore 📕 Storage 🅠 Activity	Q, Search 🖌 Ad	min					
					Л						
					۷						
		Area 🎗 User 🖉 Group									
Cytomine .	Admin A	Area 💄 User 🖆 Group	C Permission	Configuration Acts to Cyton	mine					L	ogged as: Marée Raphaël
Cytomine A	Admin A	Area 💄 User 🕿 Group	C Permission	Configuration A Back to Cytor	mine					L	ogged as: Marée Raphaël
Cytomine /	Admin A	Area 💄 User 🖀 Group	C Permission	Configuration A Back to Cytor	mine	finlane	in the second		energia e	L	ogged as: Marée Raphaéi
Cytomine / Add new id	Admin A vuser	Area LUser 🛎 Group username		Configuration Back to Cytor	¢	firstname	¢ email	¢	created \$	updated :	ogged as: Marée Raphaël
Cytomine J Add new id	Admin A vuser	Area LUcer SGroup username	C Permission	Configuration Back to Cytor	enine ÷	firstname	e enail	\$	created \$	L updated :	ogged as: Marée Raphaël
Cytomine Add new	Admin A vuser ¢ adu	Area Lucer Scroup username	C Permission	Configuration Asack to Cytor Iestname ADMIN	mine ¢	firstname	email info@cytomina.be	÷	created ≎ 2015-04-22	updated 3	egged es: Marée Raphaèl
Cytomine A Add new id 37 263700	Admin A	Area Lucer Scroup username dmin annister	C Permission	© Configuration → Back to Cytor Isstname ADMIN LANNISTER	mine ¢ Ju C4	firstname st an	email info@cytomina.be admin@utg.ac.be	¢	created ≎ 2015-04-22 10 hours ago	updated 3	egged es: Marée Raphaði
Cytomine . Add new id 37 263700 263688	Admin A v user	Area LUser Schoop username dmin annister	C Permission	© Contiguration A Back to Cytor Isstname ADMIN LANNISTER STARK	mine	firstname st an rrsei dard	email info@cytomina.be admin@utg.ac.be estark@utg.ac.be	¢	created 0 2015-04-22 10 10 hours ago 11	updated :	action action book Edit book Edit
Add new Id 37 283700 283688 30	Admin A v user	Area LUzer Croup username dmin annister stark	C Permission	Contiguration Active to Cytor Iastname ADMIN LANNISTER STARK SERVER	mine	firstname st an rosi dard ope		¢	created 0 2015-04-22 2 10 hours ago 2 2015-04-22 2	updated 3 2015-04-22 Yesterday	 action bio Est bio Est
Add new Id 37 2635060 30 263868	Admin A vuser adu cla cla cla innu jen	Area Luerame username dmin contractor atark stark	C Permission	Contiguration Active Lastname Lonuistren Stark Serven SNOW	smine ¢ Ju Ju C4 E6 Im Jo	firstname st an dard dard	email info@cytomina.be admin@ug.ac.be estark@ug.ac.be info@cytomina.be johranow@ug.ac.be	¢	created ¢ 2015-04-22 10 hours ago 2 2015-04-22 2015-04-22 10 hours ago 2	updated 3 2015-04-22 Yesterday	ection ec

Note: on our demo instance, we do not provide admin codes to avoid issues due to unintentional operations. If you install the software on your servers, an admin user will be created by our automated installation procedure (username/password is requested during installation).

6.2.3 Upload and manage images

A user can upload images to its storage and then associate images to project(s). The user has to click on the "Storage" button (top black bar) to access the Storage panel where he can select (drag & drop or "Add files" dialog box) images from its local computer and link them automatically to a given project. If multiple files are to be uploaded, start upload will upload five of them in parallel:

Cytomine O Dashboard 🗏 Projects O Explore 💄 Storage	9 Activity				Ø About Us - LSnow Jon (jsnow) -
• Upload					
Important notes ! The maximum file size (ser file) for uploads is 100 GB Only image files (JPE)G, PNG, BMP, THE, TFF, JPEX, SVS, BVS J22 VMS and MIXS's must be abped the VMS/MSME file and their nearbo- A Zp file containing multiple image is allowed (except for VMS) and MI You can deng & deng file fine may use factors on the Add files. Denty You are also able to link images with project manually after upload is d	K, SCN, NDPL, VMS, MRXS) are allowed If like. One zip per image. XS) with Google Chrome, Mozilla Firefox and Apple Satari. one.				
Storage	jsnow storage			•	
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MULLER-LAB-ZEBRAFISH-20.jpg	2015-08-11 13h42	0.19Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-19.jpg	2015-06-11 13h41	0.18Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-18.jpg	2015-08-11 13h41	0.18Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-17.jpg	2015-08-11 13h41	0.17Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-16.jpg	2015-08-11 13h41	0.17Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-15.jpg	2015-08-11 13h41	0.18Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-14.jpg	2015-06-11 13h40	0.18Mo	application/octet-stream	DEPLOYED	Delete
MULLER-LAB-ZEBRAFISH-13.jpg	2015-06-11 13h40	0.18Mo	application/octet-stream	DEPLOYED	Delete

The bottom table lists all images uploaded to the Cytomine instance and their current status. Once it is "Deployed", an image will appear in the user storage and selected (if any) project image list. Some images require additional conversion steps (e.g. non-pyramidal TIFF, or multidimensional microscopy formats supported by Bio-Formats) and will take longer than natively supported formats. The uploaded image will also be available for other projects and the User can associate it



Cytomine	🕐 Dashboard	I 🔳 Projects	Explore	📕 Storage 🛛 🌢 Activity						
DEMO-VARIOU	JS Images	Annotations	Properties	Configuration						
							+ Add new	image 🛛 🗯 Refresh		
	DE	MO-VARIOUS					Ŷ			
		10		▼ records p	per page	Searc	:h:			
		id	A Pre	view	Name	÷	Created		Action	
		264100			cells1.p	ng	2015-06-11 09h26		+ Add	
		265148			cells1.p	ng	2015-06-11 10h41		+ Add	
		265317			cells2.p	cells2.png 2015-06-11 10h-			+ Add	
		265471	•		cells5.p	ng	2015-06-11 10h41		+ Add	
		265569		3	cells4.p	ng	2015-06-11 10h41		+ Add	
		265667		5	cells3.p	ng	2015-06-11 10h41		+ Add	
		265761			cells6.p	ng	2015-06-11 10h42		+ Add	
		265869		W • * *	cells8.p	ng	2015-06-11 10h42		+ Add	
		265975			cells7.p	ng	2015-06-11 10h42		+ Add	
		266423			LUNG1	.jp2	2015-06-11 10h48		+ Add	
		Showing 1 to	10 of 175 entri	es				K 1 2 3	4 5 ≯ ₩	

to another project through the "Add Image" (blue) button in the specific Project image list:

An image can be removed from a project through the "Delete image" option in the drop down list (Arrow at the right of the explore button):

e	🕲 Dashboa	ard 🔲 Projects 🥹 🗗	plore 💻 Storage 🕠	Activity									🕄 About U	s → 💄 Snow Jon (jsno
RIOU	S Image	es Annotations Pro	perties Configuration											
							+ Add new image	Refresh						
	10			 records p 	er page				Search:					
	ID 🔻	Preview	Name	Width (px)	Height (px)	Magnitude	Resolution (µm/pixe)	User an.	Algo an.	Valid an.	Vendor	Created	Status	Action
	305162		test_upload.png	1267	720	Undefined	Undefined	0	0	0	Undefined	2015-08-11 20h09	None	Explore -
														Explore
	287464		OS-2.ndpl	126976	73728	40 X	0.227	0	0	0	HAMAMATSU	2015-06-11 13h18	None	Start reviewing
	287147	1, W	CMU-1.svs	46000	32914	20 X	0.499	0	0	0	<i>O</i> aperio	2015-08-11 13h17	None	Copy image and an Import user annotal
S	howing 1 to 3	3 of 3 entries											м	C Description
														Ownload
														Rename
														E L'eidte

<u>6.2.4 Apply Cytomine-DataMining analysis modules and proofreading</u> Our Cytomine-DataMining analysis modules can be launched from Cytomine-WebUI. It has to be



noted that other third-party modules can be similarly launched, provided they are registered as Software into the Cytomine-Core and described by a template of Software parameters.

Here we only illustrate the basic principles of these workflows on small ("toy") datasets. Obtaining satisfactory recognition performances on real-world applications depends on many factors including image variations (due to image acquisition and sample preparation protocols), and the quality and quantity of annotations provided for training. To obtain validated training sets by multiple experts, one might use the Inter-observer module (see below Section 6.2.5). Overall, our tool allows to rapidly prototype such applications by using our generic algorithms described in Supplementary Note 4. Additional research in machine learning and image analysis might produce algorithms better suited for specific applications. Our modules allow to build models by tree-based supervised learning, apply them on new images, edit results, and re-apply learning procedures based on enhanced training sets.

6.2.4.1 Tissue Detection and Semantic segmentation

In this example, we want to quantify the size (area) of tumor islets with respect to section sizes in whole slide (gigapixel) images. In order to produce these quantification results, we will apply four registered softwares: a Tissue Section Detector, a Tumor detector learning procedure, a Tumor detector prediction procedure, and a final procedure to output statistics (ComputerTermArea). We use the toy project DEMO-SEGMENTATION-TISSUE.

The first step (if not already done) is to associate the Software to the Project in the Project Configuration page (bottom of the page), in our case we begin with the TissueDetect software:



The user also has to activate (green) the "Jobs" tab in the "Custom UI" panel (if not already done): Now let's consider the User wants to apply the "Detect Sample" analysis module to detect its tissue sections. The user first click on the "Jobs" tab of the project, then on the "TissueDetect" software,



then on the "Run Job":

Cytomine O Dashboard 🖩 Projects O Explore 🚔 Storage	Activity	O About Us - LSnow Jon (jsnow) -
_DEMO-SEGMENTATION-TISSUE Images Annotations Properties	Jobs Configuration	
Software available	Spftware description	
0Segmentation_Model_Builder		
2Segmentation_Model_Builder	Name lissueDetect Description	
5Segmentation_Model_Predict	More details	
AutoLung2		
TissueDetect	Previous/Current Jobs	
TissueSegment_Model_Builder		
TissueSegment_Model_Predict	Users show jobs with no deleted data C Feltreeh Reset	
Actions	A Id 0 # 0 Date 0 State 0 Remove all data	Action
	No data available in table	
	Showing 0 to 0 of 0 entries	H4 < > H4

It opens a "Launch new job" dialog box to allow the User to configure the Software parameter values (the form is automatically build based on software parameter definition in the database). Here, we want to associate the term "Section" to objects detected by the procedure, and we keep default values for the thresholding algorithm:

Launch new job

Run TissueDetect on project _DEMO-SEGMENTATION-TISSUE

Name	Value	Vau cannot choses more than 4 ited	Required
cytomine_predict_term	Section ×		
cytomine_max_image_size	2000		
cytomine_erode_iterations	3		
cytomine_dilate_iterations	3		
cytomine_athreshold_blocksize	951		
cytomine_athreshold_constant	5		
Preview			
		Close	Create new job

This will add an entry to the "Previous/Current jobs" panel. The job will be executed and Status is displayed and updated during execution. It can be seen by clicking on the "Details" blue button. This also displays parameter values of the running job:



Cytomine 🎯 Dashboard 🗐 Projects 👁 Explore 💂 Storage	Activity					🛿 About Us 🗸	LSnow Jon (jsnow) -	
Software available	Software description							Г
0Segmentation_Model_Builder								
2Segmentation_Model_Builder	Description	lissueDetect						
5Segmentation_Model_Predict		More details						
AutoLung2								
TissueDetect	Previous/Current Jobs							
TissueSegment_Model_Builder	data							
TissueSegment_Model_Predict	Just show jobs with n	no deleted data 🛛 Reset Reset						
Actions	A Id	¢# ¢Date	¢	State	Remove all data		Action	
O Run job	305364	1	2018-06-11 20837	Success	Denoto dana		Dotails	$\langle \neg$
	Showing 1 to 1 of 1 entries					н	< 1 > H	
	Job details							
	Name Launched by Date Status Data Parameters	Job 1 jenow 2016-06-11 20h97 (DECCC) Annotations						
				Search:				
	Name		Value		\$ Ту	pe		
	cytomine_athreshold_block	size	951		Nu	imber		
	cytomine_athreshold_const	tant	5		Nu	imber		
	cytomine_dilate_iterations		3		Nu	imber		
	cytomine_id_project		- 278366		Nu	imber		

Once the job has reached the "Success" status (in roughly one minute for the two images of our toy project running on our demo instance), one can see (by scrolling down) the objects detected by this job by clicking on "View Predicted galleries" (blue button) that will open the Annotations tab with the filter corresponding to this UserJob. In our case, Sections of the lung are well detected automatically:



💻 Storage 🛛 🧄 Activity		😢 About Us 👻 💄 Snow Jon (jsnow) 🛩
Data Annotations		
Parameters		
	Search:	
Name	Value	ô Type ô
cytomine_athreshold_blocksize	951	Number
cytomine_athreshold_constant	5	Number
cytomine_dilate_iterations	3	Number
cytomine_erode_iterations	3	Number
cytomine_id_project	278366	Number
Showing 1 to 5 of 11 entries		₩ < 1 2 3 > ₩
Selected Job results		
Recognition rates		
 For Section (success 100 %), algo suggest: Average : 100.00 		
Average (per class): 100.00		
View contrision matrix View predicted colleries		
٦Ļ		
V		
_DEMO-SEGMENTATION-TISSUE Images Annotations Prop	arties Jobs Configuration	
Filters	Predefined Filters	
Search in user/also annotationa	Select Delete Save current selection	
Search In reviewed annotations		
	Negative	
_DEMO-SEGMENTATION-TISSUE		
Check all Uncheck all		
	Castien	
Annotations without terms Annotations with several terms	Section	
_DEMO-SEGMENTATION-TISSUE-ONTOLOGY		
V Nogelivo		
V Tumar		
Check all Uncheck all		
	Tumor	
Users Lannister Cersei (clannister)		
Snow Jon (jsnow)		
Check all Uncheck all	Download	
	Download GSV Drawload Excel Drawload PDE	
_DEMO-SEGMENTATION-TISSUE		
0Segmentation_Model_Builder AutoLung2		
2Segmentation_Model_Builder		
11 06 2015 18:37:35		
5Segmentation_Model_Predict TissueSegment_Model_Builder		
TissueSegment_Model_Predict		

Cytomine 🎯 Dashboard 🔳 Proje

The user can then validate annotations produced by this module in all project images by using proofreading (Review) tool from the Project Image listing:

	Û					+ Add new image	C Refresh						
10			 records 	s per page				Search:					
D ,	Preview	Name	Width (px)	Height (px)	Magnitude	Resolution (µm/pixe)	User an.	Algo an.	Valid an.	Vendor	Created	Status	Action
78814	~	LUNG2.jp2	38912	32256	Undefined	Undefined	0	2	0	Undefined	2015-06-11 11h42	None	Explore -
278476 howing 1 to	2 of 2 entries	LUNG1.jp2	30720	25600	Undefined	Undefined	21	2	0	Undefined	2015-06-11 11h42	None	Start reviewing Start reviewing (Cyto) Copy image and annotations Import user annotations
													■ Description ② Download ✓ Rename 窗 Delete ● More info

"Start reviewing" (using LUNG2 image) opens the Explore view with additional "Review" tools in the right Panel. The user can then first select the Job (or User) layer from which he wants to validate annotations:





It displays the unvalidated annotations with a lighter opacity and red borders:



The user can then accept annotations one by one (by selecting the annotation, then click on "Accept" or press "A" on the keyboard) or all at one (by clicking on "Accept all"). Validated annotations are colored with the original color of the ontology Term and have green borders. Concretely, these annotations are copied into the "Reviewed" annotations of that image:





Once sections have been detected (e.g. to compute section Area), a typical application might be to detect tumor islets within them. For that, we use the Cytomine-DataMining Semantic Segmentation analysis module. We will exploit Tumor and Negative manual annotations to build a Tumor detection model, then we will use the model to segment whole slide images. As for the TissueDetect module, the software has to be added to the Project (if not already done) in the Project Configuration panel. Then the TissueSegmentModel_builder has to be run using appropriate parameter values (in our case select the current Project identifier to download annotations, the "Tumor" as predicted terms, the "Section" as excluded terms, and zoom level = 2). Learning is in general only performed once in a project (using annotations coming from this project or other ones), provided that images within a given project have similar visual appearances.

EMO-SEGMENTATION-TISSUE Images Annotations Properties	Jobs Configuration LUNG2.jp2	•	
Software available	Δ		
0Segmentation_Model_Builder	U		
2Segmentation_Model_Builder			
5Segmentation_Model_Predict			
AutoLung2	Launch new job		
TissueDetect			
TissueSegment Model Builder	Run TissueSegmen	nt_Model_Builder on project _DEMO-SEGMENTATION-TISSUE	
TissueSegment_Model_Predict	Name	Value	Required
	cytomine_annotation_projects	278306 X	*
Actions	extensine means level	check all, uncheck all	
	cytonine_zoon_level	2	
	cytomine_predict_terms	Tumor X chark all unchark all	*
	cvtomine excluded terms		
		check all, uncheck all	•
	pyxit_target_width	16	
	pyxit_target_height	16	
	pyxit_colorspace	2	
	pyxit_n_jobs	10	
	nuvit transnose		
	pyxit_fixed_size	8	
	pyxit_interpolation	1	
	forest_n_estimators	10	
	forest max features	20	
	ferest mis semples split		
	iores_inin_samples_split		
	pyxit_n_subwindows	100	



Once the Job reaches the "Success" status (in roughly one minute using our "toy" data on the demo instance), the Tumor detection model is ready to be applied to whole-slide images. The user then launch the TissueSegment_Prediction Job using appropriate parameter values (the image identifier, identifier of the TissueSegmentModel_builder job which created the model, the "Tumor" as predict term, the "Section" ROI term and activate the cytomine_reviewed_roi to only apply the model within validated Sections, zoom level = 2):

EGMENTATION-TISSUE Images Annotations Pr	roperties Jobs Configure	ttion LUNG2.jp2 👻			
ure available	Δ				
nentation_Model_Builder	U	Launch new job			
rentation_Model_Builder					
rentation_Model_Predict		Run TissueSegment_Mo	del_Predict on projec	t_DEMO-SEGMENTATION-TISSUE	
ing2		Name	Value		Required
Detect		cytomine_id_image	LUNG1.jp2 ×		•
Segment_Model_Builder		model_id_job	TissueSegment_Model_Builder 2015	-06-11 21h20 ×	ou cannot choose more than 1 item
Segment_Model_Predict		cytomine_zoom_level	2		
		cvtomine tile size	512		
		outomine tile min stilder	512		
° <,⊐		cytomine_ine_inin_atodev	5		
		cytomine_me_max_mean	260		
		cytomine_startx	0		
		cytomine_starty	0		
		cytomine_endx	0		
		cytomine_endy	0		
		cytomine_nb_jobs	10		
		cytomine_predict_term	Tumor ×		·
		cytomine_roi_term	278354		
		cytomine_reviewed_rol	1		
		pyxit_target_width	24		
		pyxit_target_height	24		
		nvit colorspace	0		
		pysit_sh_johs	2		
		outomine predict term	10	, ,	ou cannot choose more than 1 item
		Cytomine_predic_term	Tumor ×		· ·
		cytomine_roi_term	278354		
		cytomine_reviewed_roi	1		
		pyxit_target_width	24		
		pyxit_target_height	24		
		pyxit_colorspace	2		
		pyxit_nb_jobs	10		
		cytomine_predict_step	8		
		cytomine_union			
		cytomine_postproc	2		
		cytomine_min_size	1000		
		cytomine_union_min_length	10		
		cytomine_union_bufferoverlap	5		
		cytomine_union_area	5000		
		cytomine_union_min_point_for_simplify	1000		
		cytomine_union_min_point	500		
		cytomine_union_max_point	1000		
		cytomine_union_nb_zones_width	5		
		cytomine_union_nb_zones_height	5		
		cytomine mask internal holes	2		
		cytomine_count			
		cytomine_max_size	1000000		
		pyxit_post_classification	C		

Close Create new job

This procedure can take time (from minutes to hours) depending on model complexity, image sizes, resolution level, and allocated computing resources. It will create progressively annotations in tiles of the image. The process is running in the background and the user can perform other tasks meanwhile. The progress can be seen visually by opening the image and selecting in the "Annotation layer" tool the running Job, as illustrated below:





Then once all tiles are processed, the module will apply post-processing and an union procedure of all overlapping geometries. Once the whole process is done (it displays the "Success" status in the Job panel, it can take roughly 40 minutes to process this "toy" image on our demo instance), the user can review these tumor annotations using the same Reviewing procedure as for Tissue detection, by selecting the corresponding TissueSegment_Prediction job (the "Section" annotations can be hidden to ease reviewing by unselecting the box "Show" in the Ontology panel):





When most of the annotations are correct, we recommend to use the "Accept all" operations that will validate all annotations at once (they now take visually the original term color and have a green border) :



If annotations are not satisfactory at all, we recommend to annotate manually more examples (corresponding to observed predictions errors) and re-train a model. If only some annotations do not fit well the regions of interest (e.g. it misses portions of several tumor islets), the user can use proofreading tools to edit their geometries (or reject objects, e.g. tissue subtypes that are not tumor islets). Using the "t" keyboard or the "Display review layer" checkbox, the user can switch the display of the review layer for further inspection to look at the original tissue, and refine tumor contours using +/-/Fill polygon operations (+ operates an union of the draw polygon with the reviewed polygon, - subtract it):



Once the whole image is proofread, the user has to Validate the image (green button) in the right Tool panel:

REVIEW ACTION IMAGE -						
Accept all	Reject all	Validate image				



Now, it is possible to use the "ComputerTermArea" software to generate statistics about Section and Tumor area and ratios. Add the software to the project (once) in the Project configuration Panel, and run the Job:

Softwares		
Softwares	ComputeTermArea • OSegmentation_Model_Builder • SSegmentation_Model_Predict • SSegmentation_Model_Predict • SSegmentation_Model_Predict • AutoLung2 • Cell_Classifier_Float • Cell_Classifier_Validation • Stopput01ermAnae • Landmark_Model_Builder • Landmark_Model_Builder • Landmark_Model_Builder • Landmark_Model_Builder • TissueSegment_Model_Builder •	Add Creation Control C

Then run the job, select "Tumor" and "Section" as Terms, and your image, in order to generate and download a CSV file with statistics:

_DEMO-SEGMENTATION-TISSUE Images An	notations Properties Job	s Configuration						
Software available	4	7						
OSegmentation Model Builder		4						
2Segmentation_Model_Builder								
5Segmentation Model Predict		Launch new job						×
AutoLung2		·						
ComputeTermArea			project DEMO-9	SEGMENTATION-TISSUE				
TissueDetect		Name	Volue	DEGMENTATION-11000E		Poquiro	d	
TissueSegment_Model_Builder		cytomineHost	http://bata.cvtomina.ba			nequire	ru	
TissueSegment Model Predict		Tormo	Thep://www.cytomine.co					
			Tumor × Section ×		· ·			
Actions		Images	LUNG2.jp2 ×					
O Run job			check all, uncheck all					
		Preview					Close	o Create new job
	17 ÷	2015-08-12 14h09	State	Remove all data Delete data		Action Details	4	
	16	2015-08-12 14h07		Delete data		Details	~	
	15	2016-01-15 11h18 2014-01-25 01h53		Delete data		Details		
	13	2013-12-19 09h08		Delete data		Details		
	Showing 1 to 5 of 17 entries				H K 1 2	3 4	5 HI	
	Job details							
	Name Job 17							
	Launched by maree Date 2015-06-	12 14h09						
	Data Annotatio	ch SnS						
	Parameters							
				Search:				
	Name		Value	\$ Т у	0			
	cytomineHost		http://beta.cytomine.be	Str	lg Domain			
	Terms		Adénocarcinomes, Poumon	Lis	Domain			
	Showing 1 to 3 of 3 entries				144	< 1	> >>	
	Selected Job results							
	Filename	Comment	Size	View Downlos				
	report2.csv	Report	5 KB	report2.csv report2.cs	1			
				Ŷ				
				Summarize Area				
				Image 14/1350548372140/LUNG2.jp2 Total	Tumor 4742011 4742011	Section 8 118522269 8 118522269	Total 9 165942387 9 165942387	
				Summarize Number	Tumor	Section	Total	
				14/1350548372140/LUNG2.jp2 Total	13	9 3	3 142 3 142	
				Ratio Data Image	Tumor	Section	Total	
				zerzapusekarzzewicowaz.jp2 Details	0.285763	0.714237	1.00000	
				Image 1 14/1350548372140/PGP_POUMON_PGP7_412012-08-07_1	13.50.jp2			
				аллиааллиаллиааллиаа Tumor				
				Created 2012 11 29 14:10:06	Area 223442.0			
				2012.11.29 14:10.00	101401.0			
								cytomine

6.2.4.2 Object detection and classification

In this guide, we explain how to apply an object finder procedure followed by an object classification step, e.g. to classify positive and negative cells in cytology images. This example uses four softwares from the Cytomine-DataMining analysis modules: classification validation, classification model builder, object finder, and classification prediction. The provided "toy" demo project (DEMO-CLASSIFICATION-CELL) contains two main classes of cells (10 positive in red, 10 negative in blue). The goal is to build a workflow to detect and classify these cells automatically.

First, the classification validation module allows to evaluate by cross-validation classification performances of the image classification algorithm, given its parameter values and manual annotations with semantic terms. It is launched as other modules through the Jobs panel of the Project:

Cytomine O Dashboard II Projects O Explore Storage			
_DEMO-CLASSIFICATION-CELL Images Annotations Properties	Jobs Configuration		
Software available	Ŷ		
Cell_Classifier_Builder			
Cell_Classifier_Finder			
Cell_Classifier_Predict	Launch new job		
Cell Classifier Validation			
·	Run Cell_Classifier_	Validation on project _DEMO-CLASSIFICATION-CELL	
Actions	Name	Value	Required
	cytomine_zoom_level	0	
	cytomine_dump_type		
	cytomine_fixed_tile		
	cytomine_n_shifts	0	
	cytomine_annotation_projects	277246 *	•
		check all	
	cytomine_excluded_terms	Other × check all	*
	cytomine_reviewed		
	pyxit_target_width	16	
	pyxit_target_height	16	
	pyxit_colorspace	2	
	pyxit_n_jobs		
	pyxit n subwindows	1000	
	most aire size		
	Pyot_min_size		
	pyxit_max_size	1.0	
	pyxit_interpolation		
	pyxit_transpose	×	
	pyxit_fixed_size		
	forest max features	20	
	Analysis south and		
	torest_min_samples_split		
	svm	0	
	svm_c	1.0	
	cv_k_folds	10	
	cv_shuffle		
	cy shuffle test fraction	03	

Once the process reaches the "Success" state, it is possible to view recognition rates, misclassified objects, and an interactive confusion matrix of the classifier in the Job Details (click on the Blue "Details" button, then scroll down and click on the blue "View confusion matrix"). It is possible to click on the confusion matrix numbers to view galleries of cell classifications. In our example, the classifier reaches 100% recognition rate for both cell types:



≜ Id	0 H	Date	State		Remove all data		ф А
416923	8	2015-08-12 14h41		Success	Delete data		
413222	7	2015-08-12 11h47		Success	Delete data		
411985	6	2015-08-12 11h38		Running	Delete data		
410942	5	2015-08-12 11h38		Running	Delete data		
403886	4	2015-08-12 11h38		Bunning	Delete data		
Showing 1 to 5 of 8 entries							
						144	(1 2)
Job details							
Name Launched by Date Status Data	Job 8 jsnow 2015-06-12 14h41 success Annotations						
Parameters							
				Search:			
Name		*	Value			0 Туре	
cv_k_folds			5			Number	
cv_shuffle						Boolean	
cv_shuffle_test_fraction			0.3			Number	
cytomine_annotation_proje	cts		277246			ListDomain	
cytomine_dump_type			1			Number	
Showing 1 to 5 of 30 entries						HH 《 1 2	3 4 5 🕻
Selected Job results							
Recognition rates							
For Negative (success For Positive (success Average : 100.00 Average (per class) :	: 100 %), algo suggest: 100 %), algo suggest: 100.00						
View confusion matrix	View predicted galleri	20					
	ĸ	Nega.	Othe.		Posi.	to	tal
Ne	ga.	10		_	George at Targe Daviding	10	1096
Ot	he.		0		suggest Term Positive for annotation Positive		
Po	si.				10 🦛	10	10%
Atio d				6			

The classification validation module only evaluates classification models without saving them. Once satisfactory results are obtained, the user can build with corresponding parameter values and save a classification model by using the classification model builder module. It will save a model on the processing server that can be later reused by the classification prediction module (it takes less than one minute on our demo instance using our small "toy" data):

nine 🎯 Dashboard 🗏 Projects 📀 Explore ا 🗸 St

Software available	ឋ		
Cell_Classifier_Builder	Laurah anu int		0
Cell_Classifier_Finder	Launch new job		
Cell_Classifier_Predict			
Cell_Classifier_Validation	Run Cell_Classifier	_Builder on project _DEMO-CLASSIFICATION-CELL	
Actions	Name	Value	Required
	cytomine_annotation_projects	277246 ×	•
	cytomine_zoom_level	0	
	cytomine_excluded_terms	(Married	
		check all	•
	pyxit_target_width	16	
	pyxit_target_height	16	
	pyxit_colorspace	2	
	pyxit_n_jobs	10	
	pyxit_min_size	0.5	
	pyxit_max_size	1	
	pyxit_interpolation	2	
	forest_n_estimators	10	
	forest_max_features	28	
	forest min samples split		
	nut a sibuindoure	1000	
	pysccommons		
	oviii	1	
	cytomine_dump_type	1	
	cytomine_reviewed		
	cytomine_predict_terms	Contract of the second	
		check all	Ť
	pyxit_fixed_size		
	forest_shared_mem		
	svm_c	1.0	

cytomine

Now it is possible to apply this model to classify annotations of an image. We thus need before to apply an object finder to the image to create annotations corresponding to candidate objects. To ease the choice of a thresholding algorithm, it is first possible to apply standard algorithms on-the-fly, tile per tile, in the Cytomine-WebUI image explore view. The user needs first to add the image layer (in the Project Configuration panel), then apply it using the "Image Layers" panel at the right of the image Explore view:



To apply the Object finder module on an image to create annotations, the user needs to add the software to the project (once), then launch it. It will create annotation objects in the corresponding job layer (here we use zoom level=1 and adaptive thresholding algorithm on cells1 image):



Cytomine 🔿 Dashboard 🗏 Projects 👁 Explore 📇 Storage	🎝 Activity		😮 About Us 👻 💄
DEMO-CELLS Images Annotations Properties Jobs Confi	iguration cells1.png +		
Software available	Bun Cell, Classifier, Finder on	project DEMO-CELLS	
Cell_Classifier_Builder	Custom form		
Cell Classifier Finder	Pre-filled form with job template (Not available)	ie: no Job template)	
Cell_Classifier_Predict	Name	Value	Required You cannot choose more than 6-item
Cell_Classifier_Validation	cytomine_id_image	cells1.png ×	•
	cytomine_tile_size	256	
Actions	cytomine_zoom_level	1	
	cytomine_tile_overlap	0	
	cytomine_filter	adaptivo	
	cytomine_union_min_length	10	
	cytomine_union_bufferoverlap	Б	
	cytomine_union_area	5000	
	cytomine_union_min_point_for_simplify	1000	
	cytomine_union_min_point	500	
	cytomine_union_max_point	1000	
	cytomine_union_nb_zones_width	5	
	cytomine_union_nb_zones_height	5	
	cytomine_predict_term	Other ×	
	cytomine_min_area	0	
	cytomine_max_area	10000	

Once the job has reached its "Success" (less than one minute for one image on our demo instance) status, detected objects can be seen in "View predicted galleries" (blue button in the "Details" of the job) or directly in the Explore view of that image:



Now, we can apply a classifier to these detected objects in the image, by launching the classification prediction module (Cell_Classifier_Model_Predict), using the previously built classifier model, and the previously found candidate annotations (using the identifier of the job which generated these objects):



Cytomine 🕲 Dashboard 🗏 Projects 🔮 Explore 🗸 Storage	 Activity 			Ø About Us ◄
DEMO-CELLS Images Annotations Properties Jobs Confi	iguration cells1.png -			
Software available				
Cell_Classifier_Builder	Launch new job			
Cell_Classifier_Finder				
Cell Classifier Predict	Bun Cell, Classifier, P	redict on project DEMO-CELLS		
Cell_Classifier_Validation	Custom form			
	Pre-filled form with job template	(Not available: no Job template)		
Actions	Name	Value	Required	
	model_id_job	Cell_Classifier_Builder 2015-06-13 22h54 ×	Tou calnot choose more than 1 nem	
	outomine id image		You cannot choose more than 1 item	
	Gytomine_id_image	cells1.png ×	•	
	cytomine_zoom_level	0		
	cytomine_id_userjob	Cell_Classifier_Finder 2015-06-13 20:41:19.859 ×	You cannot choose more than 1 form	
	cytomine_dump_type	1		
			Close Create n	iew job

Once the classifier has reach its "Success" status (it takes less than one minute on our demo instance using annotations detected in cells1.png image), it is possible to visualize its classifications (as another job layer, either in the Explore view, or as "Predicted galleries" in the Annotation tab through the Details of the job).

DEMO-CELLS Images Annotations Properties Jobs Cont	iguration
Filters Search in userslags annotations Generic in reviewed annotations	Predefined Filters Sector Serve current selection
DEMO-CELLS Oncek al Uncheck al	Undefined
Accolations without terms Accolations with several terms	Multiple
DEMO-CELLS DEMO-CELLS DEMO-CELLS DEMO Transformer Tra	Negative
Users Hoyoux Ranaud (rhoyoux) Mariée Raphaéi (mareo) Crawk at Utocheck at	
DENO-CELLS Cell Classifier_Finder Cell Classifier_Finder Cell Classifier_Predict 10 00 2015 80-510 Cell Classifier_Validation Cell Classifier_Validation	Positive
Refresh annotations Refresh job listing	

In this toy example, the classifier perfectly classifies cells (one positive in green, others negative).





As in the tissue detection application, these annotations can be reviewed by an expert. We have developed a specific "Review (Objects)" module to review object classifications in a more efficient way. It can be launched from the Project image listing:

	🕑 Dashboo	rd 🔲 Projects 👁 Exp	ore 📕 Storage	🌢 Activity									🕄 About Us 🗸	LMarée Raphaël (rr	maree) -
LLS	Images	Annotations Properti	es Jobs Con	figuration cells	1.png +										
	仑						+ Add new image	Refresh							
	5			 record 	s per page				Search:						
	ID 🗸	Preview	Name	Width (px)	Height (px)	Magnitude	Resolution (µm/pixe)	User an.	Algo an.	0 Valid an.	Vendor	Created	Status	Action	
	131654	11.1	cells4.png	1169	1027	Undefined	Undefined	1	2	0	Undefined	2015-06-07 12h48	None	Explore -	
	131532		cells5.png	1381	981	Undefined	Undefined	1	0	0	Undefined	2015-06-07 12h47	None	Explore +	
	130795	ц. Ц.	cells2.png	2445	1279	Undefined	Undefined	5	18	0	Undefined	2015-06-07 12h39	None	Explore •	
	130789		cells1.png	2405	1375	Undefined	Undefined	6	85	0	Undefined	2015-06-07 12h39	None	Explore -	
4	Showing 8 to	9 of 9 entries											M	Start reviewing Start reviewing (Copy image and Import user anno	Dyto) annotations tations
														 Description Download Rename Delete More info 	

This module allows to select a user/job layer and displays galleries of its predictions (using pagination across all annotations). The user can then either accept these classifications, or correct them by drag'n'drop into visual boxes corresponding to the correct term. Validated and corrected annotations are copied to the Review layer of that image.





6.2.4.3 Landmark detection

In this guide, we explain how to use the landmark detection module on a "toy" dataset of Zebrafish embryo images. This example uses two softwares from the Cytomine-DataMining analysis modules: Landmark_Builder and Landmark_Predict. The provided "toy" demo project (DEMO-LANDMARK-ZEBRAFISH) contains five landmarks for 20 images, and 10 unlabelled images. The goal is to build a workflow to detect these landmarks automatically in the unlabelled images.

This module uses examples of landmarks positioned in images to build landmark recognition models. Here is an example of 5 manual landmarks on Zebrafish alizarin red images:



As previously, to launch the learning procedure, the user first needs to add the software Landmark_Model_Builder to its project (if not alreay done) in the Project Configuration panel:



Softwares		
Softwares	LandMark_Predict	Add 💭
	LandMark_Builder	Remove
	LandMark_Predict	Remove

Then, it launches the training algorithm (the algorithm will use all landmark UserAnnotations from images of this project):

Cytomine O Dashboard 🗄 Projects 👁 Explore 🚔 Storage	🌢 Activity			😮 About Us 🗸
_DEMO-LANDMARAFISH-TRAINING Images Annotations Prope	arties Jobs	Configuration		
Software available	ن			
LandMark Builder		Launch new job		
LandMark_Predict				
Actions		Run LandMark_B	uilder on project _DEMO-LANDMARK-ZEBRAFISH-TRAINING	
		Custom form	numlate (Net excitation as tak template)	
		Name	Value	Required
		cytomine_id_term	Vou cannot choose more than 1 LANDMARK-1 X	.em
		model_njobs	10	
		model_R	20	
		model_RMAX	500	
		model_P	3	
		model_npred	50000	
		model_ntrees	100	
		model_ntimes	3	
		model_angle	30	
		model_depth	ø	
		model_step	1	
		model_wsize	8	
			Close	e Create new job

This procedure will generate a model to detect a single landmark. If multiple landmarks have to be

detected, the training procedure should be repeated for other landmarks. Once a job has reached the "Success" status (it takes roughly 5 minutes per landmark on our demo instance with default parameter values), its model can be used to predict landmarks in other images. In this guide, we created models for landmark 1 to landmark 5 using 20 manually annotated images.

Applying models to predict landmarks is done by launching the Landmark Model Predict module and by selecting the previously build models:

Cytomine O Dashboard 🗏 Projects 📀 Explore 🚊 Storage 🕠	Activity	🕄 Abo
_DEMO-LANDMARAFISH-TRAINING Images Annotations Propertie	s Jobs Configuration	
Software available	$\hat{\mathbf{U}}$	
LandMark_Builder		
LandMark_Predict		
Actions	Launch new job	×
	Run LandMark_Predict on projectDEMO-LANDMARK-ZEBRAFISH-TRAINING	
	 Custom form Pre-filled form with job template (Not available: no Job template) 	
	Name Value	Required
	models_id_job [LandMark_Baider 2015-00-15 21h49 ×] LandMark_Baider 2015-00-15 21h49 ×] LandMark_Baider 2015-00-15 21h49 ×] LandMark_Baider 2015-00-15 10h04 ×]	-
	check all, uncheck all	
	Close	Create new job

In our case, it will create Point annotations corresponding to the five predicted landmark positions in all 30 project images (it takes roughly 12 minutes on our demo instance with default parameter



values). Here we illustrate predictions for a training image (the Figure shows both manual and predicted landmarks to assess position precision, one can observe slight shifts only) and an unlabled image for which no manual annotation was provided for training the model:



As with other modules, the user can now proofread these detections on new images. From the listing of images of the project, the user selects the "Review" function:

	1	}			+ A4	ld new image 🛛 🕄 Refresh							
10		• record	s per page				Search:						
ID 🔻	Preview	Name	0 Width (px)	Height (px)	Magnitude	Resolution (µm/pixe)	User an.	Algo an.	Valid an.	Vendor	Created	0 Status	Action
480316	24	MULLER-LAB-ZEBRAFISH-31.jpg	2576	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	In review	Explore •
480310		MULLER-LAB-ZEBRAFISH-32.jpg	2576	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	Review Review (Cyto)
480304	2×	MULLER-LAB-ZEBRAFISH-33.jpg	2576	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	Cancel Reviewing Validate image
480298	S.C.	MULLER-LAB-ZEBRAFISH-34.jpg	2576	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	Copy image and annotation Import user annotations
480292	8:0	MULLER-LAB-ZEBRAFISH-35.jpg	2576	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	Description Download
480286	a se	MULLER-LAB-ZEBRAFISH-36.jpg	2578	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	✓ Rename
480280	3	MULLER-LAB-ZEBRAFISH-37.jpg	2578	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	More into
480274	-	MULLER-LAB-ZEBRAFISH-38.jpg	2578	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	Explore 💌
480268	5.*·	MULLER-LAB-ZEBRAFISH-39.jpg	2578	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h45	None	Explore 💌
480216	24	MULLER-LAB-ZEBRAFISH-40.jpg	2576	1932	Undefined	Undefined	0	8	0	Undefined	2015-06-15 15h44	None	Explore +

It opens the image in the Explore view with reviewing tools activated. The user first selects the UserJob layer in the right panel. When most of the landmarks are well detected, we recommend to use the "Accept all" function (Points now have a green border) and then use the "Drag" tool (click on the landmark to edit) to move landmarks that are not well detected only:





Once all landmarks are well positioned, the user validates the image (green button). Reviewed landmark positions can later be exported to derive morphometric measurements.

6.2.5 Textual search

In addition to content-based image searching and user interface tools to filter annotation based on semantic terms, it is possible to perform textual searches through Cytomine-WebUI using http://demo.cytomine.be/#search-

Searching will be performed across data entities (projects, images, annotations, domains, properties, descriptions) that are accessible by the user. In the example below, the user looks for "Laboratory Tumor Development Biology" and the search engine displays a project that contains these words in its description:

Cytomine O Dashboard 🗐 Projects 👁 Explore ا Storage	by Activity	Q About Us → LSnow Jon (jsnow) →
	Laboratory Turnor Development Biology Search	
There are 1 result		
	decorrigition [, HSGs LABORATORY (LABORATORY of TUMOR & DEVELOPMENT BIC, Jr, (LABORATORY of TUMOR & DEVELOPMENT BICLOGY, GIInops_LABORATORY of TUMOR & DEVELOPMENT BICLOGY, GIGCompc, Universe[, Jr, of TUMOR & DEVELOPMENT BICLOGY, GIGA-Cancer, University of L[_]	Voor previously solved filters Doletes safected filter Do you want to create a new filter ? Name : Solve current filter
		Filter by project Type or dick have Filter by domain Show A1 Only Project Only Image Only Annotation Where to search Show A1 Only Domain Only Property Only Description

6.2.6 Online users

Cytomine can perform the tracking of all user activites (user positions in images are stored in the database) that e.g. allows multiple users to follow remotely another user observation paths and actions. Online users appear in the project dashboard, and in the Explore Annotation layers panel.



Cytomine	🕑 Dashboard	Projects	Explore	📕 Storage	🌢 Activity			Ø About Us -	LSnow Jon (jsnow) -
DEMO-SEGM	ENTATION-TISSUI	E Images	Annotations	Properties	Jobs	Configuration			
			🔳 DEM	O-SEGMEN	TATION-T	SSUE			
		ť	Revie See us	Ontolog Image User annotation Job annotation wed annotation took project	ay _DEMC 38 2 18 21 18 908 18 150 5	SEGMENTATION-TISSUE-ONTOLOGY	Description This projects contains whole-silde histology (H&E) images of mouse lungs provided by Didler Cataldo's laboratory (Laboratory of Tumor & Development Biology, GIGA-Cancer, University of Liège). See full text and edit		
		c	Snow Ja L Snow Ja	on (jsnow) UNG2.jp2 er Cersei (clanni: on (jsnow)	ster)				

It is possible to follow another online user (in green) by checking the closest box next to the user name. Once the followed user moves in the gigapixel image or creates an annotation, the following user explore view will move to the same position and display novel annotations. Geographically distributed users can thus discuss remotely in front of the same image areas (using e.g. instant messaging or phone calls).



6.2.7 Blind assessment

6.2.7.1 Blind configuration

Cytomine has a blind mode that can be activated by administrators of a project in its Configuration Panel. This option will hide (for non-admin users) in Cytomine-WebUI image names (in the Image listing, the Explore view, ...) so that the user quantifying experimental outcomes is blinded to the experimental setting that might appear in original filenames. This option also hides user activities and annotation statistics. This option might be used to reduce bias in analyzing imaging data.



Cytomine O Dashboard 🗏 Projects 🤇	Explore 💂 Storage 🥠	Activity									9 About	Us≁ ≜ Snow Jon (jsnow
Configurations	General Configurati	ion Configur	ation									
General Configuration General Configuration Default Layers Configuration Custon UI Configuration	⊟ H	ide admins layers		If you check "Hide layers.	e admin layers", a "simple" proje	ct user will not be al	ole to see the layer	of a project admin. A	. project admin will	still be able to see all		
 Image filters Softwares Private Annotation Tools Configuration 	□ H	ide users layers		If you check "Hide	e user layers", a "simple" project	user will not be able	e to see a layer from	n an other user. A pro	oject admin will stil	I be able to see all layers.		
		lind Mode		If blind mode is e								
	R	ead-Only project		If you check read be able to see to	l-only project, a "simple" project add/edit or delete data for this p	user will not be able roject.	to add/edit or delet	e data except annota	ition on his own la	ver. A project admin will still		
Cytomine O Dashboard E Projects OEMO-SEGMENTATION-TISSUE Images	Explore Storage .	Activity Jobs [BLIND]	278814 👻							e	About Us -	Lannister Cersei (clannister)
10	records per page			+ Add new image C Refrech								
ID Preview	Name	Width (px) Height (px)		Magnitude	Resolution (um/pixe)	User an.	Algo an.	 Valid an. 	Vendor	Created	Status	Action
278814	[BLIND]278814	38912	32256	Undefined	Undefined	0	906	150	Undefined	2015-06-11 11h42	In review	Explore 💌
278476	(BLIND)278476	30720	25600	Undefined	Undefined	21	2	0	Undefined	2015-06-11 11h42	None	Explore 💌
Showing 1 to 2 of 2 entries											141	< 1 > H
DEMO-SEGMENTATION-TISSUE Images	Annotations Properties	Jobs										
ACTIVITY												
Last commands Last tasks												
Not available in blind mode!												
I ANNOTATIONS VS TERM												
Not available in blind mode!												
II ANNOTATIONS VS TERM												
Not available in blind mode!												

6.2.7.2 Cytomine-IRIS: Measuring Inter-observer Reliability

In contrast to the intentionally collaborative nature of the Cytomine-Core and Cytomine-WebUI annotation modules, Cytomine-IRIS, the inter-observer reliability study module, provides an intuitive web interface for blind assessment of annotations. It is based on the public Cytomine REST API described in section 6.3 to leverage existing Cytomine backend functionality like project and user management, or annotation services for manipulating ontology terms of annotations. On the other hand, it provides a completely decoupled user interface. In addition to the basic project configuration done using the regular Cytomine-WebUI, particular projects and images can be disabled per user on IRIS, such that for example within existing projects only few images are used for assessing the inter-observer reliability among particular users.

IRIS Installation

Since Cytomine-IRIS is an additional module, multiple instances of IRIS running on different servers can be connected to a single Cytomine-Core server. Thus, the installation of IRIS differs a bit and is detailed on <u>https://github.com/cytomine/Cytomine-IRIS</u>.



In contrast to previous sections, this user guide is based on larger dataset not yet publicly available and therefore it is not directly reproducible on our demo instance (<u>http://demo-iris.cytomine.be/iris/index.html#/</u>) but main functions are presented here to allow users to apply these concepts on a reduced "toy" dataset or on their own data.

Annotation Labeling and Reviewing

The structure of a standard Cytomine project is reflected in the workflow of IRIS: once a user logs into IRIS, a list of available projects is shown, where particular projects may be disabled just for this IRIS instance. In order to start labeling, the user opens a project and views a list of available images which contain the annotations:

Cytomine IRIS	Projects	Images	Sector Labeling	 Annotations					🕑 Help	👤 Kainz F	Philipp (pkainz) 👻
You are working on:	Project [IRIS_DE	MO] > Image [[BLIND]15163799	4] > Annotation [151	638900]						
					You have acces	Refresh	S.				
		Na	ame ÷		Created -	# Images ¢	# Annotations ¢	Mode ¢	Actions	Info	
	IRIS_DEMO				2014-12-21	14	155	Blind Mode	Open 👻	0	
	IRIS_EMPTY-PRO	DJECT		Locked	2014-12-04	0	0	Regular	Open 🝷	0	
	MEDUNIGRAZ-B	ONE-MARROV	/	Locked	2014-10-03	56	4171	Blind Mode	Open -	0	
	SVS-J2K			Locked	2014-02-04	5	1	Regular	I Statistic	s Dashboar	d
	MEDUNIGRAZ-B	ONE-MARROV	/-DEV	Locked	2014-01-14	4	144	Blind Mode	Settings Coordination	ator Reques	st
:	Showing project 1	to 5 (5 in total)							Request	Access	

The image table also reflects the overall labeling progress within each image and provides functions for sorting and filtering. For example, this enables the user to filter out all images, where annotations are left to be labeled. This is particularly useful in situations where the study protocol requires all users to label all annotations, or when there are lots of images in a project.

tomine IRIS	Projects	🖪 Images	Sector Labeling	III Annotations			🤁 Help 💄 Kain:
are working on:	Project [IRIS_DE	MO]					
	ID \$	Prev	/iew	Name ÷	Magnification	Progress -	Actions
						Show all Hide completed	
15	51637961	Ut		[BLIND]151637961 50,455 x 31,589 px	40 X	100% finished	Start Labeling -
15	51637967		10mm 2003	[BLIND]151637967 40,935 x 32,578 px	40 X	100% You labeled 8 of 8 annotations.	Start Labeling -
18	51637987	1		[BLIND]151637987 51,407 x 35,368 px	40 X	100% finished	Start Labeling -
18	51665529			[BLIND]151665529 56,640 x 39,163 px	40 X	100% finished	Start Labeling -
15	51637955	1		[BLIND]151637955 55,215 x 36,845 px	40 X	62% 3 more to go	Start Labeling +
15	51637994			[BLIND]151637994 42,839 x 18,942 px	40 X	52% 24 more to go	Start Labeling +
18	51637949	JG	D	[BLIND]151637949 51,407 x 26,989 px	40 X	35% 11 more to go	Start Labeling +

The annotation labeling can be performed per image in a dedicated view by selecting "Start Labeling" from the rightmost column. Image zooming and panning is available like in the main Cytomine-WebUI, allowing proper exploration of the image context of an annotation in order to



make an informed decision about the label. The user can hide annotations where a label already exists and thus just navigates through unlabeled annotations, while their order is preserved.

Navigation among annotations can be done either using the buttons above the image view or by pressing the keys "n" for the next, or "p" for the previous annotation. A label is assigned by simply selecting the term in the table on the right hand side, which is basically a flat representation of a possible hierarchical ontology:

Cytomine IRIS	Projects	🛤 Images	🗣 Labeling	Annotations				🤂 Help 👤 Ka	inz Philij	
ou are working on:	Project [IRIS_DE	MO] > Image [[BLIND]1516379	94] > Annotation [151638900]						
	d Hide comple	eted		23 more to go		54%				
		E04_Orth	ochromatic Norm	oblast	Ass	sign a label by selection		Remove label		
	« Previous	filtered #7	Annotation # 7 /	/ 51 Next »		Name -	Category/	Class \$		
	-			0	_	E01 Pronormobilast	Erythropoiesis			
			4			E02_Basophilic Normoblast	Erythropoiesis			
						E03_Polychromatophilic Normoblast	Erythropoiesis			
	O.C.	0.0				E04_Orthochromatic Normoblast	Erythropoiesis			
	100		A			E05_Reticulocyte	Erythropoiesis			
					1 m 65 /	105		E06_Erythrocyte	Erythropoiesis	
	212					G01_Myeloblast	Granulopoiesis			
		1.1				G02_Promyelocyte	Granulopoiesis			
	17					G03_Myelocyte	Granulopoiesis			
	H					G04_Metamyelocyte	Granulopoiesis			
	The second			6		G05_Band Cell	Granulopoiesis			
						G06_Granulocyte	Granulopoiesis			
		Reset vi	ew Pan to annot	ation		M01_Megakaryocyte	Megakaryopoiesis			
		1	/iew in Cytomine			Z00_Unknown	root			
		_				Z01_Lymphocyte	root			
						Z02_Plasma Cell	root			
						Z99_Background	root			
								40 05 50 400		

It is convenient to view annotations in a gallery-like view per ontology term, which can be done by selecting "Annotations" from the menu bar at the top. This enables users to visually filter out outliers that do not comply e.g. with the appearance of the majority of annotations having the same label. Moreover, the gallery can display annotations across different images in a project and provides several methods to correct the label either directly or by navigating to the labeling view, if more context around the annotation is required. Multiple objects can also be re-assigned labels at once, which drastically reduces the time of manually navigating to the corresponding images and finding these annotations in the labeling view.





IRIS Sessions

In some scenarios, a single image may contain hundreds of annotations that sometimes cannot be assessed at once. Finding the exact annotation to continue is tedious and thus, IRIS preserves the current status of labeling across logins in sessions, such that the user can continue labeling at the exact same point where the application has been left last time. This can be done by simply going to any IRIS page and clicking on the current image name below the menu bar, or pressing the "r" key on the keyboard, which takes the user back to the labeling view in order to resume the labeling.

Interface Documentation: Help Pages

Each view in IRIS has a dedicated help page that is accessible from the main menu bar (top right corner) or by pressing the "h" key. The pages contain instructions on how to handle the interface.

IRIS Project Coordination

The standard Cytomine user management is extended in IRIS by granting special rights to particular users: the IRIS project coordinators. Each user can request to become a project coordinator and they are authorized once as such by the administrator of the IRIS instance. Coordinators are able to view and visualize project statistics such as histograms of assigned ontology terms for all users or annotation agreements. Each of these visualizations also comes with a variety of filters for particular users, ontology terms and images. Moreover, they can manage project and image access settings for all users and authorize other users to become a project coordinator. Communication among access request and authorization is handled via email, using the email address encoded in the Cytomine User Account page.

Dashboard: User Statistics

The distribution of assigned terms can be evaluated for one or more users in the Statistics Dashboard of each project from the project table (project coordinators). This enables a quick



examination, for example, of whether one or more users are biased towards assigning a particular label. This also gives a clear picture of how many terms have already been assigned by the users with respect to the total number of assigned terms and the total number of available annotations.



The coordinator can combine several filters (users, ontology terms, images) to meet the current requirements of the query.

Dashboard: Observer Agreements per Annotation

Inter-observer variability of labeled annotations can be visualized in the Statistics Dashboard of a project by selecting the tab titled "Annotation Agreements".

Cytomine IRIS IProjects	🖾 Images 🛛 🔖	Labeling III Annotations		• Help	💄 Kainz Philipp (pkainz) 👻						
You are working on: Project [IRIS_DE	MO]										
User Statistics Annotation Agree	Jser Statistics Annotation Agreements										
Project Users show			C Refresh								
Check all Uncheck all	Agreement Le	vel 📕 🗌 0 u	sers (0%)	Showing a	nnotation 1 to 10 (101 in total)						
Ontology: BM-01 hide		Annotations		Users							
	Preview	Agreement	masslaber	pkainz	rmaree						
Z00_Unknown Z01_Lymphocyte Z02_Plasma Cell	6	G03_Myelocyte 🛕 100% (1	G03_Myelocyte, assigned by 1 of 1 u: Varning: This label has been assigned by	velocyte user only!							
Z99_Background Erythropoiesis E01_Pronormoblast E02_Receptilie	0	E02_Basophilic Normo ▲ 50% (1) G02_Promyelocyte ▲ 50% (1)	E02_Basophilic Normoblast	G02_Promyelocyte							
Coc_basoprinic Normoblast E03_Polychromatophilic Normoblast	0	E03_Polychromatophil		E03_Polychromatophilic Normoblast							

From the filter panel on the left hand side, a coordinator can construct the query and a list of annotations is shown. In addition, this result list can be filtered by annotation agreements using the "Agreement Level" slider at the top of the list. This slider's maximum value corresponds to the total



number of observers that assigned any label in the query. So if the slider is moved to the right, the agreement level increases and filters out annotations, where at least n or more observers are agreeing on one or more terms. Moving it to the right usually shrinks the list and hence all annotations in the smaller list have a higher level of inter-observer agreement.

	🖬 Images 🛛 🗣 L	abeling III Annotations		Help	👤 Kainz Philipp (pkainz) 👻			
You are working on: Project [IRIS_DEMO]								
User Statistics Annotation Agreements								
Project Users whow								
Check all Uncheck all Agreement Level 2 users (67%) Showing annotation 1 to 4 (101 in total)								
Ontology: BM-01 Nde Annotations			Users					
	Preview	Agreement	masslaber	pkainz	rmaree			
Z00_Unknown Z01_Lymphocyte Z02_Plasma Cell	0	E04_Orthochromatic N 67% (2 G01_Myeloblast ▲ 33% (1	E04_Orthochromatic Normoblast	E04_Orthochromatic Normoblast	G01_Myeloblast			
 ✓ Z99_Background ▼ Erythropoiesis ✓ E01_Pronormoblast ✓ E02_Bacephilic 		E01_Pronormoblast 67% E05_Reticulocyte	O1_Pronormoblast, assigned by 2 of 3 users U E01_Pronormoblast	E01_Pronormoblast	E05_Reticulocyte			
Normoblast E03_Polychromatophilic Normoblast		E02_Basophilic Normo 100% (2	E02_Basophilic Normoblast	E02_Basophilic Normoblast				

6.3 Usage (API documentation)

Cytomine documentation is available on <u>http://doc.cytomine.be/</u> A documented RESTful API is continuoulsy updated and accessible online at <u>http://demo.cytomine.be/restApiDoc/?doc_url=http://demo.cytomine.be/restApiDoc/api</u># If you install your own Cytomine instance, this documentation is also automatically installed on your server by our automated installation procedure and then available at: http://\$CORE_URL\$/restApiDoc/?doc_url=http://\$CORE_URL\$/restApiDoc/api#

This API is used both by Cytomine-WebUI (including Cytomine-IRIS) and Cytomine-DataMining analysis modules. It can also be used by third-party software. Code examples that encapsulate http requests in Java and Python are provided here:

- <u>https://github.com/cytomine/Cytomine-java-</u> <u>client/tree/master/src/main/java/be/cytomine/client/sample</u>
- <u>https://github.com/cytomine/Cytomine-python-client/tree/master/client/examples</u>

Web users can inspect communications between their web browser and Cytomine components through the "Network" tab in the "Inspect Element" (Google Chrome)/"Inspector" (Mozilla Firefox) module of their web browser:



Cytomine O Dashboard		Explore	💂 Storage	Activity							0/				Î
_DEMO-SEGMENTATION-TISSUE	E Images	Annotations	Properties	Configuration											
Filters Search in userialgo annota Search in reviewed except	itions			Predefined Filters	ourrent solection										
_DEMO-SEGMENTATIO Check all Uncheck all	DN-TISSUE			Undefined											
Annotations without terms Annotations with several te	irms			Multiple											
DEMO-BEGAMENTATIC Vogative Voga	DN-TISSUE-ON	TOLOGY		Negative			Ì								
Stark Eddard (esta	urk) Limeline Deofiler	Paraurrar Aud	te Concola										017.0		
 Q Y View: II Sources 1 Q Y View: II Sources 1 	s: Preserve log	Disable cache	6 (0160)e										•1/ 44	∠∕3γει	
		M XHR Scr	ipt Style Images	Media Fonts Documents	WebSockets Other 🛛 Hide da	ta URLs									
2.00 s 4.00 s	6.00 s	8.00 s	10.00 s	1200 s	16.00 s 18.00 s	20.00 5 22.00 5	24.00 s	26.00 s 28.00 s	30.00 s 3	34005	36.00 5 38.00 5	40.0	- = -	s 44	00 s 7
Name			Method	Status Type	Initiator	Size	Time	Timeline	10.00 s	15.00 s 20.00 s	25.00 s 90.0	10 s	85.00 s 40.	1.00 s	45.
annotation.json?&project=278366&noTem	n=true&users=2636	768reviewed=fal	GET	200 shr	jquery-20.3.min.js/6		252 B	64 ms							
annotation ison?8project=2783668multipl	1283488users=3434	265676889View	GET	200 shr	jquery-20.3 minjs6 imanu 20.9 minist		252.8	68 ms							
annotation.json?eproject=2783668tarm=2	278348005855=2030 178354800685=2636	766reviewed=1a	GET	200 xhr	imany 20 3 min infi		252.0	60 ms							
annotation.ison?&project=2783668.term=2	2783608/users=2636	5768reviewed=fa	GET	200 xhr	iquery-2.0.3.min.ist6		6.8 KB	92 ms						1	
annotation.json?8project=2783668.noTerm	n=true&users=2636	76,2637008.revie	GET	200 xhr	iquery-20,3.min.ist5		252 B	51 ms						1.1	1
annotation.json?8project=2783668multipl	leTerm=true&users=	263676,263700	GET	200 xhr	iquery-2.0.3.min.jss6		252.8	58 ms							î.
annotation.json?8project=2783668.term=	2783488/users=2636	576,263700&revie	GET	200 xhr	jquery-2.0.3.min.jst6		6.8 KB	84 ms							τ.
annotation.json?8project=2783668.term=2	2783548users=2636	576,263700&revie	GET	200 xhr	jquery-20.3.min.js5		252 B	75 ms							11
annotation.json?8 http://demo.cytomine.b 85 requests 2.6 MB transferred	e/api/annotation.jsc	on?&project=27836	6&term=278354&user	s=263676,263700&reviewed=false&r	ax-308offset-081434026363212		6.8 KB	91 ms							17
CS-2.ndpi + Annulé												4	· Afficher tous les téle	léchargements	×

In addition, the API online documentation includes a "Playground" for each web service that allows the user to test server responses according to user input (e.g. here we use the service to get annotation description given an annotation identifier):

JSONDoc http://beta.cytomine.be/restApiDoc/api#	Get documentation	
API INFO Base patth: http://beta.cytomine.be Version: 0.1	USER ANNOTATION SERVICES Methods for managing an annotation created by a human user	PLAYGROUND /aphaerservedstory[d] jern
	/api/userannotation/[id].json	GET Accept
APIS	Path /api/userannotation/fid).ison	e application/jeon
AMOP Queue configuration services	Description Get a user annotation	Path parametere
RestProjectDefault_averController	Method CET	r att parametera
abstract image services	Produces	id 152928410
acl services	ann i cation/ison	
algo annotation services	Bath parameters	Submit
annotation filter services	id Benired the	
annotation index service	Tune loop	
annotation term service	Description: The exception of	Response text Response info Request info
attached services	Description: The amount of	
description services	Response object	
discipline services	Object user annotation	"class": "be.cytomine.ontology.UserAnnotation", "id": 152928410.
generic amotation services	Errors	"created": "1422535263409",
image filter project services	400 Bad Request: missing parameters or bad message format	"updated": null,
image filter services	401 Unauthorized: must be auth	"location": "POLYGON ((24608 20586, 24638 20584, 24642 20580, 24686 20572, 2468
image group services	403 Forbidden: role error	8 20568, 24766 20546, 24806 20540, 24838 20528, 24874 20524, 24946 20504, 24958 2
image instance services	484 Object not found	0504, 24964 20500, 25018 20488, 25018 20484, 25030 20480, 25054 20476, 25094 2045 2, 25120 20430, 25150 20420, 25176 20396, 25188 20392, 25210 20374, 25222 20370,
image sequence services		25222 20366, 25236 20362, 25240 20356, 25260 20352, 25270 20344, 25292 20310, 252
job parameter services	/api/userannotation.json	92 20220, 25284 20192, 25266 20176, 25254 20172, 25226 20152, 25222 20144, 25198 20124, 25162, 20108, 25164, 20006, 25134, 20076, 25134, 20076, 25144, 25074, 25074, 25074, 25074, 25074, 25074
job services		58, 25086 20036, 25082 20036, 25074 20036, 25154 20076, 25114 20074, 25084 200 58, 25086 20036, 25082 20036, 25074 20018, 25034 19988, 25006 19980, 25002 19976,
job template annotation services	/api/userannotation.json	24990 19976, 24970 19966, 24890 19944, 24882 19940, 24882 19936, 24870 19936, 248
job template services	/api/userannotation/[id].json	DELETE 19876, 24774 19876, 24730 19856, 24628 19848, 24626 19868, 24734 19688, 24734 19888, 24734 19888, 24538 198
message broker services	/api/userannotation/(id) ison	20, 24544 19820, 24526 19832, 24514 19834, 24504 19844, 24494 19844, 24434 19868,
ontology services		78 19926, 24362 19954, 24356 19958, 24346 19980, 24342 19980, 24342 19980, 24342 20018, 24326
project services	/api/userannotation/[id]/crop.json	20032, 24326 20040, 24312 20064, 24306 20098, 24286 20168, 24286 20208, 24298 202
property services	/api/project/{id}/userannotation/download	GET 24, 24318 20264, 24332 20278, 24334 20290, 24342 20298, 24342 20304, 24354 20318, 24380 20400, 24404 20436, 24418 20486, 24438 20516, 24476 20552, 24482 20552, 244
relation services		98 20572, 24510 20576, 24512 20580, 24608 20586))",
relation term services	rapirusein(uyuseianindtatiotr/count.json	"inoge": 7889170,
reviewed annotation services	/api/annotation/{userannotation}/comment.json	Post "project": 7873585,
roi annotation services	/api/annotation/(userannotation)/comment/(id).json	GET "container": 7873585, "user": 14,
search engine filter services	/api/annotation/(userannotation)/comment.json	GET "nbComments": 0, "area": 223768,



The following table give some examples of URLs to export data (using jsnow username account on demo.cytomine.be):

URL example	Description
http://demo.cytomine.be/api/user.json	List of users (JSON)
http://demo.cytomine.be/api/user/263676.json	Description of a specific user (JSON)
http://demo.cytomine.be/api/project.json	List of projects (JSON)
http://demo.cytomine.be/api/project/528050.json	Descrpition of a specific project (JSON)
http://demo.cytomine.be/api/project/528050/ima geinstance.json	List of images in a specific project (JSON)
http://demo.cytomine.be/api/imageinstance/5284 60.json	Description of a specific image (JSON)
http://demo.cytomine.be/api/abstractimage/5281 20/thumb.png?maxSize=1024	Thumbnail of a specific image (PNG)
http://demo.cytomine.be/api/annotation.json? &project=528050	List of annotations in a specific project (JSON)
http://demo.cytomine.be/api/annotation.json? &project=528050&term=528044&users=26367 6&images=528132	List of annotations of a specific ontology term, in a specific project, for a specific user (human or userjob), in a specific image (JSON)
http://demo.cytomine.be/api/annotation/528401.j son	Description of a specific annotation (JSON)
http://demo.cytomine.be/api/userannotation/528 401/crop.png	Crop image of a specific annotation (PNG)
http://demo.cytomine.be/api/userannotation/528 401/crop.png?increaseArea=2	Crop image of a specific annotation (PNG) with context
http://demo.cytomine.be/api/userannotation/528 401/crop.png?zoom=2	Crop image of a specific annotation at zoom level 2 (PNG)
http://demo.cytomine.be/api/userannotation/528 401/crop.png?zoom=2&mask=true	Crop binary mask of a specific annotation at zoom level 2 (PNG)
http://demo.cytomine.be/api/userannotation/528 401/crop.png?zoom=2&alphaMask=true	Crop alpha mask of a specific annotation at zoom level 2 (PNG)
http://demo.cytomine.be/api/imageinstance/5284 60/window-23181-14285-1000-1000.png	Tile of size 1000x1000 at a specific location (23181,14285) in a specific image (PNG)
http://demo.cytomine.be/api/imageinstance/5284 60/window-23181-14285-1000-1000.png? mask=true&review=true&terms=528044	Tile reviewed mask of size 1000x1000 at a specific location (23181,14285) for a specific ontogy term in a specific image (PNG)
http://demo.cytomine.be/api/job/1939560.json	Description of a specific job (JSON) including software parameter values

