
TissUUmaps

Release 3.0

Nicolas Pielawski	Axel Andersson
Christophe Avenel	Andrea Behanova
Eduard Chelebian	Anna Klemm
Leslie Solorzano	Fredrik Nysjö
	Carolina Wählby

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This page hosts the documentation for TissUMaps 3.0. You can find a pdf version of this documentation [here](#).

For more information on the TissUMaps project, including [video tutorials](#) and [demos](#), visit our website: <https://tissuums.github.io>.

Work in progress!

This page is mostly empty for now. We are working actively on writing this documentation, more content will be available soon!

INTRODUCTION

1.1 About TissUMaps

[TissUMaps](#) is a free and open source browser-based tool for GPU-accelerated visualization and interactive exploration of tens of millions of datapoints overlaying tissue samples. Users can visualize markers and regions, explore spatial statistics and quantitative analyses of tissue morphology, and assess the quality of decoding in situ transcriptomics data. TissUMaps provides instant multi-resolution image viewing, can be customized, shared, and also integrated in Jupyter Notebooks. We envision TissUMaps to contribute to broader dissemination and flexible sharing of large-scale spatial omics data.

Currently, microscopy data can be cumbersome to share: physically transferring the images is often necessary and dedicated software must be installed. Instead, researchers can now share their findings with a simple link to a website running TissUMaps. The images are loaded in real time, together with annotations, markers, and masks that may also be modified by the user. We also provide tools for quality control and image processing. The software is designed to display and interact with images at multiple resolutions and large numbers of markers, especially data from spatially resolved omics techniques and tissue atlases. TissUMaps is compatible with many different bioimage informatics tools, and provides new ways to develop insights when exploring and sharing data.

You can access the [TissUMaps project gallery](#) with interactive examples to explore data from in situ sequencing and spatial transcriptomics experiments and view localized quantification of cell and tissue morphology, including links to publications. For seeing examples of TissUMaps compatibility with other platforms you can access the [tutorials page](#).

1.2 Installation

[TissUMaps](#) is a browser-based tool for fast visualization and exploration of millions of data points overlaying a tissue sample. TissUMaps can be used as a web service or locally in your computer, and allows users to share regions of interest and local statistics.

1.2.1 Windows installation

1. Download the Windows Installer from [the last release](#) and install it. Note that the installer is not signed yet and may trigger warnings from the browser and from the firewall. You can safely pass these warnings.

1.2.2 PIP installation (for Linux and Mac)

1. Install libvips for your system: <https://www.libvips.org/install.html>

An easy way to install libvips is to use an [Anaconda](#) environment with libvips:

```
conda create -y -n tissuumaps_env -c conda-forge python=3.9 libvips
conda activate tissuumaps_env
```

2. Install the TissUMaps library using pip:

```
pip install "TissUMaps[full]"
```

3. Start the TissUMaps user interface:

```
tissuumaps
```

4. Or start TissUMaps as a local server:

```
tissuumaps_server path_to_your_images
```

And open <http://127.0.0.1:5000/> in your favorite browser.

1.3 Citing TissUMaps

Please cite our [preprint](#) on bioRxiv if using TissUMaps in your work:

TissUMaps 3: Interactive visualization and quality assessment of large-scale spatial omics data. *Nicolas Pielawski, Axel Andersson, Christophe Avenel, Andrea Behanova, Eduard Chelebian, Anna Klemm, Fredrik Nysjö, Leslie Solorzano, Carolina Wählby*, bioRxiv 2022.01.28.478131; doi: <https://doi.org/10.1101/2022.01.28.478131>.

1.4 Changelog

1.4.1 3.0.8.6

- Make it possible to update to newer version of plugins
- Fully support `--debug` option in command line
- Add tooltip title for piecharts
- Add documentation <https://tissuumaps.github.io/TissUMaps-docs/>
- Fix marker picking when pixel ratio != 1
- Other minor fixes and cleaning

1.4.2 3.0.8.5

- Minor fixes.

1.4.3 3.0.8.4

- Add tiling to viewport capture for higher resolution output
- Increase resolution of markers on high resolution devices
- Fix jumps on pan with mouse gesture (mobile)
- Add fix for bright image canvas on Safari
- Add an option to remove markers' outlines.

1.4.4 3.0.8.3

- Fix png artifact in Firefox, by generating jpg tiles.

1.4.5 3.0.8.2

- Add high resolution capture of viewport, up to 4096x4096 pixels.

1.4.6 3.0.8.1

- Fix multiple dataset alignment when no background image

1.4.7 3.0.8

- Fix black images generated by VIPS
- Fix Linux and Mac open of captures
- Auto save datasets as buttons when saving tmap projects
- Add mpp (microns per pixel) option in tmap files, to add scale bar to viewer
- Make region line thickness depend on zoom level
- Add compatibility with JupyterLab
- Add opacity per marker option

1.4.8 3.0.7

- Add menu to load plugins through an update-site

1.4.9 3.0.6

- Fix multiple plugins opening always last plugin
- Move to OpenSeadragon 3.0.0
- Add tooltip format in Advanced Settings
- Add drag and drop to open CSV files and images
- Add “Add layer” button for flask version
- Add viewport capture

1.4.10 3.0.5

- Move csv loading to Papa Parse streaming, to allow better memory management

1.4.11 3.0.4

- Add filtering of markers

1.4.12 3.0

- Add tissuumaps.jupyter module

GETTING STARTED

2.1 Images

2.1.1 Supported image formats

TissUMaps can read whole slide images in any format recognized by the OpenSlide library:

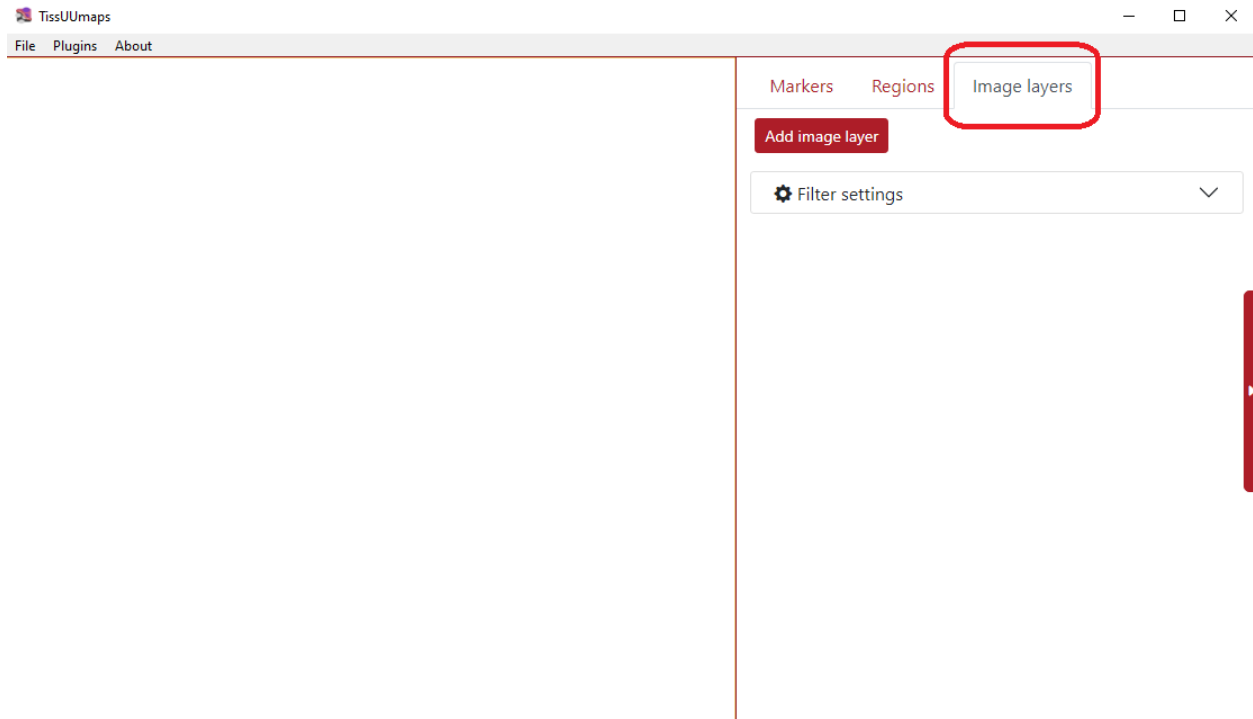
- Aperio (.svs, .tif)
- Hamamatsu (.ndpi, .vms, .vmu)
- Leica (.scn)
- MIRAX (.mrxs)
- Philips (.tiff)
- Sakura (.svslide)
- Trestle (.tif)
- Ventana (.bif, .tif)
- Generic tiled TIFF (.tif)

TissUMaps will automatically convert any other format into a pyramidal tiff (in a temporary `.tissuums` folder created in the original image folder) using `vips`.

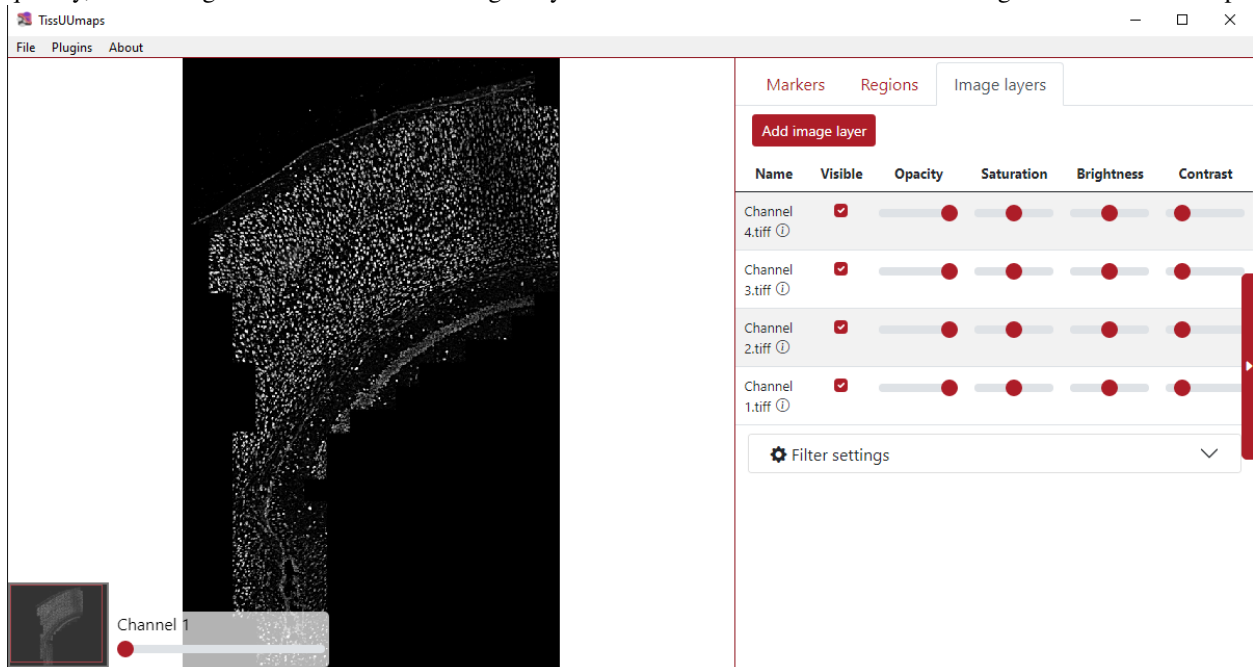
If your image fails to open, try converting it to `tif` format using an external tool.

2.1.2 Load images

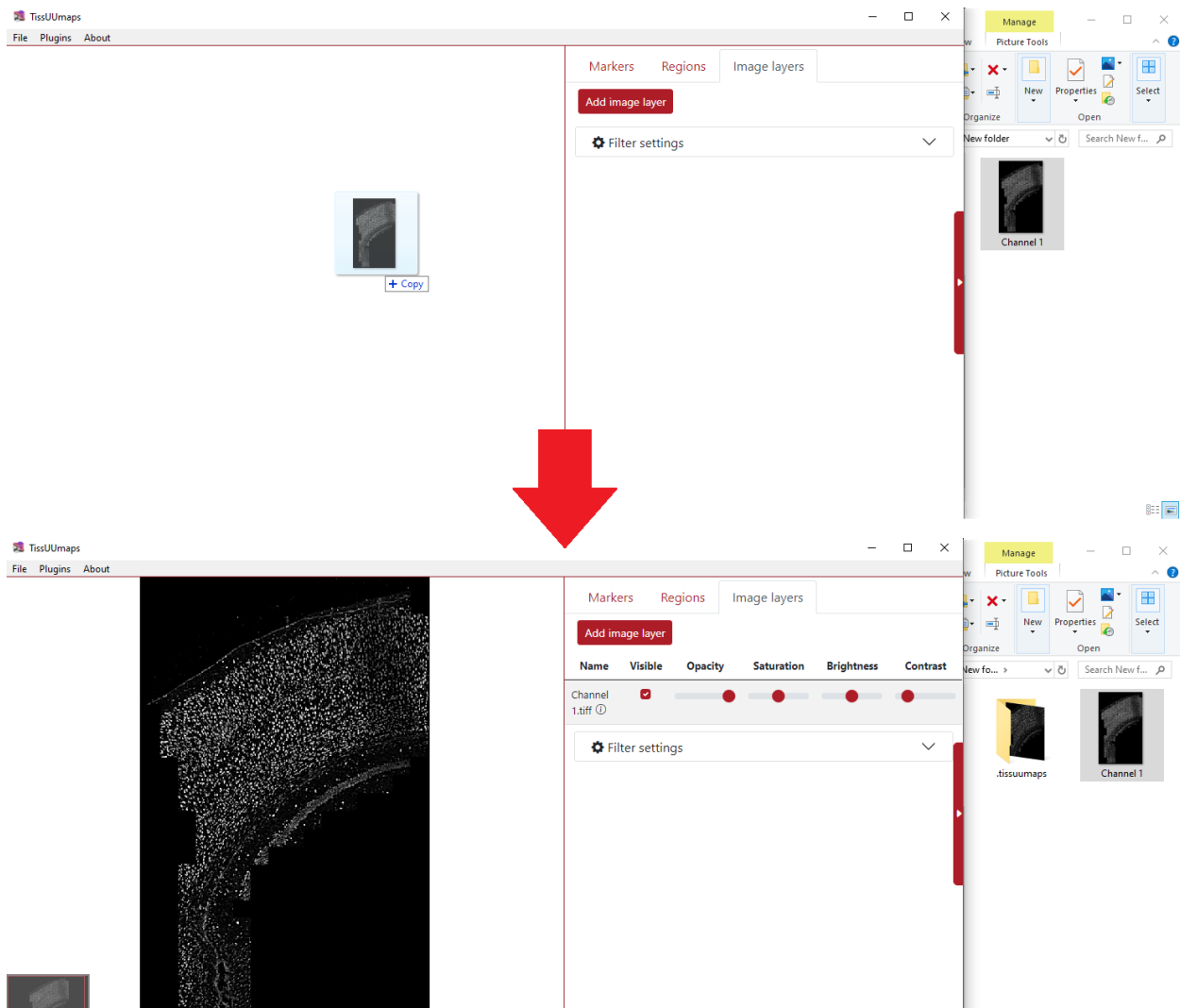
You can load the images when you select the Image layer tab as you can see in the figure below:



Then click the button Add image layer and select the desired image from your computer. Subsequently, the image is listed in the Image layer tab. You can load several images into TissUMaps.





You can also drag and drop the image from file explorer into TissUMaps.



2.1.3 Apply filters


You can apply several filters to the images. The ones we can be adjusted by default are saturation, brightness, and contrast. Additionally, when opening the Filter settings menu, there are various other filters, such as exposure, noise, erosion, etc. When you check their box, they are automatically added to the filter panel above. The filter's sliders can be adjusted so that the filter is applied at the desired intensity. Another option in filter settings is merging mode (bottom part), where you can merge the channels as a composite.

Name	Visible	Opacity	Saturation	Brightness	Contrast
Channel 1.tiff ⓘ	<input checked="" type="checkbox"/>	<input type="range"/>	<input type="range"/>	<input type="range"/>	<input type="range"/>

 Filter settings 

- ☐ Color
- ☒ Brightness
- ☐ Exposure
- ☐ Hue
- ☒ Contrast
- ☐ Vibrance
- ☐ Noise
- ☒ Saturation
- ☐ Gamma
- ☐ Invert
- ☐ Greyscale
- ☐ Threshold
- ☐ Erosion
- ☐ Dilation

Merging mode:

Channels 

2.2 Markers

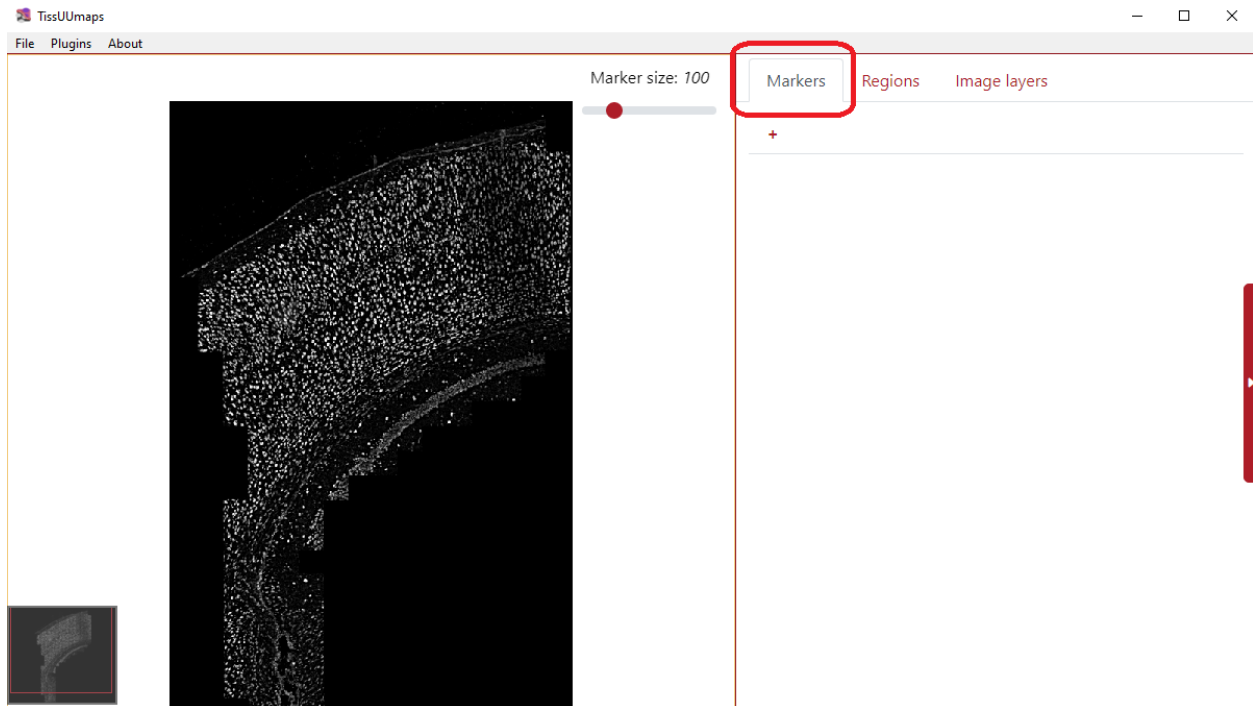
2.2.1 Supported marker format

TissUUmapi can read CSV (Comma Separated Values) files with a header row, and at least spatial coordinate columns (X and Y). CSV files are not limited in the number of columns or number of rows. Other columns can contain information for displaying markers (key to group markers, color, size, shape, piecharts, etc.)

CSV files can be exported from any spreadsheet program, or any programming language (Python, R, etc.)

2.2.2 Load markers

You can load the markers when you select the Markers tab and click the button + as you can see in the figure below. You can click the plus several times to load various marker files.



2.2.3 Markers settings

Before the markers are displayed you have to set up the markers settings.

File and coordinates

The first step is to select the desired file from your computer under the tab File and coordinates - Choose file.

 The screenshot shows the 'File and coordinates' settings panel. At the top, there is a 'New markers' button with a red plus sign next to it. Below this, there is a red header bar with the text 'File and coordinates' and a red upward-pointing arrow. Under the header, there are two main sections. The first section is 'File and coordinates', which contains a 'Choose File' button and a text input field with the value 'coordinates.csv'. The second section is 'Tab name', which contains a text input field with the value 'New dataset'. Below these sections, there are two dropdown menus: 'X coordinate' and 'Y coordinate', both of which currently show '----' and a downward-pointing arrow.

You can change the Tab name to the desired name, so it is easier to navigate between them when there are more tabs.

Genes × +

File and coordinates ^

File and coordinates

Choose File

coordinates.csv

Tab name

Genes

X coordinate

----- ▾

Y coordinate

----- ▾

The next step is to select the column names from the .csv file corresponding to the X and Y coordinates.

Genes × +

File and coordinates ^

File and coordinates

Choose File

coordinates.csv

Tab name

Genes

X coordinate

----- ▾

genes

X

Y

Y coordinate

Y ▾

----- ▾

----- ▾

Render options

Here, you can define a key to group by, what is a column from the .csv file which will be used to display the dataset grouped by different colors and shapes of the markers. In this example, we use the column genes, where different colors and shapes of markers represent different genes.

Render options



Group by

Key to group by (optional)

----- ▼

genes

X

Y

Color options

- ☒ Color by group
- ☐ Color by marker
- ☒ Generate color from key value
- ☐ Generate color randomly
- ☐ Use color from dictionary
- ```
{'key1':'#FFFFFF',...}
```

There is an option to display an extra column, for example when the data are clustered but you want to see the original genes and also the cluster names.

## Render options



## Group by

Key to group by (optional)

genes ▼

Extra column to display (optional)

----- ▼

-----

genes

X

Y

- ☐ Color by group
- ☐ Color by marker
- ☐ Generate color from key value
- ☐ Generate color randomly
- ☐ Use color from dictionary
- ```
{'key1':'#FFFFFF',...}
```

In Color options, you can select to color by groups where each group has a different color. Then on the right side, you can select the color palette:

- Key value - Colors are generated from the name of the group (first 4 letters). Groups starting with the same letter have similar colors.
- Randomly - Colors are generated randomly.
- Dictionary - you can insert a specific dictionary in the text area which will be used for generating the colors.

Render options

Group by

Key to group by (optional)

genes

Extra column to display
(optional)

Color options

☒ Color by
group

☐ Color by
marker

☒ Generate color from key value

☐ Generate color randomly

☐ Use color from dictionary

```
{'key1':'#FFFFFF',...}
```

If you want to color by markers, you have to select the column from the .csv file which will be used to create the colors, and the colormap, but only if the color column is numeral.

Render options

Group by

Key to group by (optional)

genes

Extra column to display
(optional)

Color options☐ Color by
group☒ Color by
marker

Select color column

Color map (only if color column is
numeral)

None

Advanced options**Table of markers**

2.3 Regions

2.3.1 Supported region formats

TissUUmapi can read and write region files in the [GeoJSON](#) format.

Only a subset of the GeoJSON format is supported, as TissUUmapi uses only polygonal regions:

Main types:

- Feature
- FeatureCollection
- GeometryCollection

Geometries:

- Polygon
- Multipolygon

The coordinate system must be the same as the image and marker coordinate systems.

2.3.2 Draw Regions

2.3.3 Analyze Regions

2.3.4 Load Regions

2.3.5 Export Regions

2.4 Projects

2.4.1 Saving and loading projects

For more information on the tmap file format and specifications, see *The TMAP file format*.

2.5 Exporting screenshots

TissUUmapi allows high resolution capture of the image viewport. Go to **Menu > File > Capture viewport** and chose a zoom factor for export (1 = screen resolution).

The screen capture will contain all filtered layers, markers, and regions. Note that legends will not be part of the export and must be added manually.

2.6 Plugins

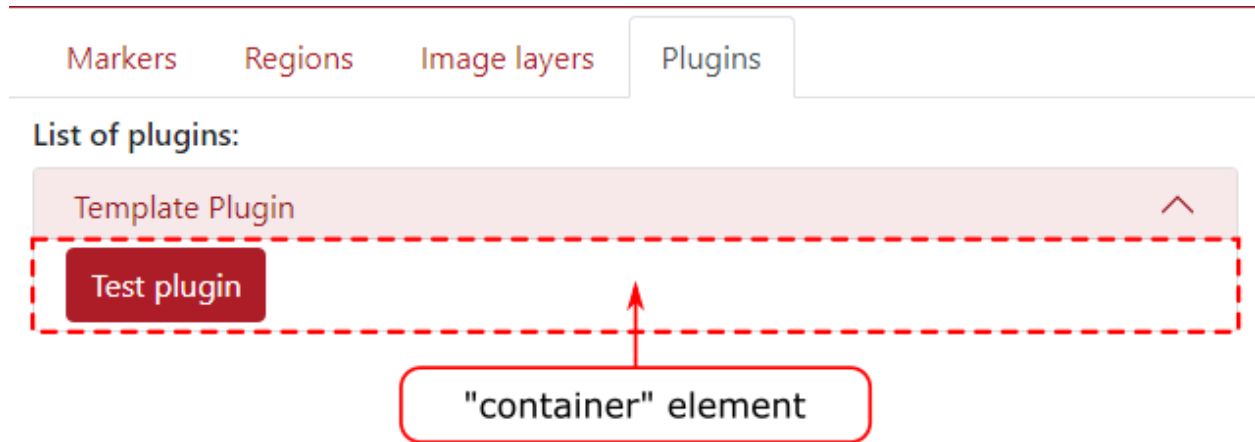
2.6.1 Load plugins

2.6.2 Make your own plugin

Download the Plugin Template python and javascript files from the [Plugin Update Site](#) and put both files in your local folder \$USER_PATH/.tissuumapi/plugins/. You can then change the plugin name and add your own options and functions.

Javascript file

When loading a plugin, the function `PluginName.init(container)` will be called. The `container` is an html Element that will be added to the plugin menu. Use this element to add options and texts related to your plugin.



Here is a minimal example of plugin:

```
var Plugin_template;
Plugin_template = {
  name: "Template Plugin"
}

/**
 * This method is called when the document is loaded.
 * The container element is a div where the plugin options will be displayed. */
Plugin_template.init = function (container) {
  container.innerHTML = "Hello world";
}
```

You can access the TissUUmapi javascript API [here](#).

Python file

You only need to use the Python file if your plugin needs to do processing on the server side. For pure javascript plugins, you can leave this file empty.

The python file should implement the class Plugin:

```
class Plugin ():
  def __init__(self, app):
    self.app = app
```

The app object being the flask application running the TissUUmapi server.

You can call a Python method inside the Plugin class from Javascript using Ajax and the Python API. The endpoint for a method methodName of the plugin PluginName will be: /plugins/methodName/functionName. Data can be transmitted through Ajax as stringified JSON, and will be available as a parameter inside the method.

See the Plugin Template for a working example of Javascript / Python communication.

SHARING PROJECTS

3.1 Apache server

TissUMaps projects can be exported into static webpages, that can be uploaded to any Apache server.

1. Save your project from TissUMaps (menu > File > Save project)
2. Export to static page (menu > File > Export to static webpage)
3. Copy the exported folder on your Apache server

3.2 Docker container

1. Start the docker container `cavenel/tissuums:latest` from Docker Hub:

```
docker run -it -p 56733:80 --name=tissuums -v /path/to/local/images:/mnt/data cavenel/  
↪tissuums:latest
```

1. Place your images in the local folder `/path/to/local/images/share`.
2. Open <http://127.0.0.1:56733/> in your favorite browser.

ADVANCED USAGE

4.1 Jupyter notebooks

TissUMaps can easily be used inside a Jupyter Notebook or Jupyter Lab.

Simple example to load an image in TissUMaps:

```
import tissumaps.jupyter as tj
viewer = tj.loaddata(["image.png"])

viewer.screenshot()
```

4.1.1 tissumaps.jupyter

Module used to run TissUMaps from a Jupyter Notebook or from Jupyter Lab.

`tissumaps.jupyter.opentmap`(*path*, *port*=5100, *host*='localhost', *height*=700)

Open a tmap project

Parameters

- **path** (*str*) – The path to a tmap file
- **port** (*int*) – The port to run the TissUMaps server
- **host** (*str*) – The host to run the TissUMaps server
- **height** (*int*) – The height of the jupyter iframe

Returns The TissUMaps viewer

Return type *TissUMapsViewer*

`tissumaps.jupyter.loaddata`(*images*=[], *csvFiles*=[], *xSelector*='x', *ySelector*='y', *keySelector*=None, *nameSelector*=None, *colorSelector*=None, *piechartSelector*=None, *shapeSelector*=None, *scaleSelector*=None, *fixedShape*=None, *scaleFactor*=1, *colormap*=None, *compositeMode*='source-over', *boundingBox*=None, *port*=5100, *host*='localhost', *height*=700, *tmapFilename*='_project', *plugins*=[])

Load data in TissUMaps

Parameters

- **images** (*list* | *str*) – List of images or single image to display
- **csvFiles** (*list* | *str*) – List of csv files or single csv file to display

- **xSelector** (*str*) – Name of the csv column defining the X coordinates
- **ySelector** (*str*) – Name of the csv column defining the Y coordinates
- **keySelector** (*str*) – Name of the csv column defining the grouping key
- **nameSelector** (*str*) – Name of the csv column defining the group name
- **colorSelector** (*str*) – Name of the csv column defining the group color
- **piechartSelector** (*str*) – Name of the csv column defining pie-charts
- **shapeSelector** (*str*) – Name of the csv column defining markers' shape
- **scaleSelector** (*str*) – Name of the csv column defining markers' scale
- **fixedShape** (*int*) – Name of the markers' shape
- **scaleFactor** (*int*) – Global scale of markers
- **colormap** (*str*) – Name of the colormap used if colorSelector is set
- **compositeMode** – (*str*): Composite mode used for images
- **boundingBox** (*list*) – [X,Y,W,H] of the bounding box to display
- **port** (*int*) – The port to run the TissUMaps server
- **host** (*str*) – The host to run the TissUMaps server
- **height** (*int*) – The height of the jupyter iframe
- **tmapFilename** (*str*) – Name of the project file that will be created
- **plugins** (*list*) – List of plugins to add to the tmap project

Returns The TissUMaps viewer

Return type *TissUMapsViewer*

class `tissuums.jupyter.TissUMapsViewer(server, image, height=700)`

Class representing a TissUMaps viewer instance

screenshot()

Capture the TissUMaps viewport and display image in the Notebook.

class `tissuums.jupyter.TissUMapsServer(slideDir, port=5000, host='0.0.0.0')`

Class representing a TissUMaps server instance

4.2 Napari

Napari features an important hub containing 118 plugins at the time of writing, many of them expanding further the capabilities of Napari when dealing with biomedical imaging. We thus created our own plugin to allow users to work in Napari, benefit from the tools, scripting and existing plugins, and easily visualize and share the output of their research through TissUMaps.

The [Napari-TissUMaps plugin](#) is available on Napari Hub which makes the installation trivial: from the Napari install/uninstall plugins menu, the `napari-tissuums` appears in the list and can be installed with a single click. Alternatively, the plugin can be installed with the Python package manager: `pip install napari-tissuums`.

The plugin can export all standard Napari layers, such as images, labels, points, and shapes and preserves the metadata (opacity, visibility), but also the objects parameters (e.g.: label colors, marker colors and symbols, etc...). To export a TissUMaps project, care must be taken to save all layers of interest and type in a name with the extension `.tmap`, e.g.: `myProject.tmap`. This is important for Napari to delegate the saving of the files to the plugin. A folder is created

and contains all the necessary files and can be loaded in the TissUMaps server, software, Jupyter Notebook, or shared with the community.

The project folders generated by the plugin contain the metadata in a `main.tmap` file, along with folders for each Napari layer types: images, labels, points and regions. Images and labels are saved as plain tif images, points are saved as CSV files, and shapes are saved as GeoJSON. We hope that the use of a simple structure and widespread file formats can simplify the modifying and updating of the TissUMaps project when prototyping with e.g. Jupyter Notebooks. The source code is available at <https://github.com/TissUMaps/napari-tissuums> under the permissive MIT license. A demonstration of the Cellpose plugin of Napari being exported to the TissUMaps web viewer is available at: <https://tissuums.github.io/tutorials/#napari>.

4.3 AnnData

Work in progress

4.4 The TMAP file format

The TMAP format contains a description of image layers, markers, regions, and settings. It is highly recommended to create `.tmap` files by saving projects from TissUMaps, but you can also edit the files manually to add or change projects' settings, or generate them as exported data from other software for import in TissUMaps.

The TMAP format uses JSON, with the following specifications:

4.4.1 TMAP project specifications

Description of image layers, markers, regions, and settings of a project. Required properties are shown in bold text			
type	<i>object</i>		
properties			
• filename	Name of the project		
	type	<i>string</i>	
• layers	type	<i>array</i>	
	default	[]	
	items		
	•	<i>Layer</i>	
• layerOpacities	type	<i>object</i>	
	patternProperties		
	• ^[0-9]+\$	type	<i>integer</i>
• layerVisibilities	type	<i>object</i>	
	patternProperties		
	• ^[0-9]+\$	type	<i>boolean</i>
• layerFilters	type	<i>object</i>	
	patternProperties		

continues on next page

Table 1 – continued from previous page

	<ul style="list-style-type: none"> • $^{[0-9]+\\$}$ 	<i>LayerFilter</i>
<ul style="list-style-type: none"> • filters 	List of filters shown as active filters in the GUI under the Image layers tab	
	type	<i>array</i>
	default	["Saturation", "Brightness", "Contrast"]
	items	
	<ul style="list-style-type: none"> • 	<i>Filter</i>
<ul style="list-style-type: none"> • compositeMode 	Mode defining how image layers will be merged (composited) with each other. Valid string values are "source-over" and "lighter", which correspond to 'Channels' and 'Composite' in the GUI.	
	type	<i>string</i>
	default	source-over
<ul style="list-style-type: none"> • mpp 	The image scale in Microns Per Pixels. If not null, then adds a scale bar to the viewer. Set to 0 to display the scale bar in pixels.	
	type	<i>float</i>
	default	null
<ul style="list-style-type: none"> • boundingBox 	Bounding box used to set initial zoom and pan on the view when loading the project.	
	type	<i>object</i>
	default	null
	properties	
	<ul style="list-style-type: none"> • x 	Left coordinate of the bounding box in pixels
		type <i>float</i>
	<ul style="list-style-type: none"> • y 	Top coordinate of the bounding box in pixels
		type <i>float</i>
	<ul style="list-style-type: none"> • width 	Width of the bounding box in pixels
		type <i>float</i>
	<ul style="list-style-type: none"> • height 	Height of the bounding box in pixels
		type <i>float</i>
<ul style="list-style-type: none"> • rotate 	Angle of rotation of the view in degrees. Only multiples of 90 degrees are supported.	
	type	<i>integer</i>
	default	0
<ul style="list-style-type: none"> • markerFiles 	type	<i>array</i>
	default	[]
	items	
	<ul style="list-style-type: none"> • 	<i>MarkerFile</i>
<ul style="list-style-type: none"> • regions 	GeoJSON object, see <i>Regions section</i> .	
	type	<i>object</i>
	default	{}
<ul style="list-style-type: none"> • regionFile 	(Deprecated) GeoJSON region file loaded on project initialization. Use regionFiles instead.	
	type	<i>string</i>
	default	
<ul style="list-style-type: none"> • regionFiles 	type	<i>array</i>
	default	[]
	items	

continues on next page

Table 1 – continued from previous page

	<ul style="list-style-type: none">	<i>RegionFile</i>	
<ul style="list-style-type: none">plugins	List of plugins to load with the project. See also the <i>Plugins section</i> .		
	type	array	
	default	[]	
	items		
	<ul style="list-style-type: none">	type	string
<ul style="list-style-type: none">hideTabs	Hide tabs of markers dataset. Only use when you have a unique marker tab.		
	type	boolean	
	default	false	
<ul style="list-style-type: none">settings	type	array	
	default	[]	
	items		
	<ul style="list-style-type: none">	Setting	

Layer

Description of an image layer. Required properties are shown in bold text		
type	object	
properties		
• name	Name of the image layer	
	type	string
• tileSource	Relative path to an image file in a supported format. See also the <i>Images section</i> .	
	type	string

LayerFilter

Description of an image filter to be applied to the pixels in an image layer. Required properties are shown in bold text		
type	array	
items		
•	type	object
	properties	
	• name	Filter name. See <i>Filter</i> for more details.
		type string
	• value	Filter parameter. See <i>Filter</i> for more details.
		type string

Filter

TissUMaps supports most filters available in OpenSeadragon via the https://github.com/usnistgov/OpenSeadragonFiltering plugin.	
enum	Color, Brightness, Exposure, Hue, Contrast, Vibrance, Noise, Saturation, Gamma, Invert, Greyscale, Threshold, Erosion, Dilation

ColorScale

TissUMaps supports most of the color scales available in the D3.js library. See https://github.com/d3/d3-scale-chromatic for reference. Note: the colors for 'interpolateRainbow' are currently overridden by a custom Turbo-like color scale in version 3.0.x of TissUMaps.	
enum	interpolateCubehelixDefault, interpolateRainbow, interpolateWarm, interpolateCool, interpolateViridis, interpolateMagma, interpolateInferno, interpolatePlasma, interpolateBlues, interpolateBrBG, interpolateBuGn, interpolateBuPu, interpolateCividis, interpolateGnBu, interpolateGreens, interpolateGreys, interpolateOrRd, interpolateOranges, interpolatePRGn, interpolatePiYG, interpolatePuBu, interpolatePuBuGn, interpolatePuOr, interpolatePuRd, interpolatePurples, interpolateRdBu, interpolateRdGy, interpolateRdPu, interpolateRdYlBu, interpolateRdYlGn, interpolateReds, interpolateSinebow, interpolateSpectral, interpolateTurbo, interpolateYlGn, interpolateYlGnBu, interpolateYlOrBr, interpolateYlOrRd

Shape

TissUMaps supports most of the marker shapes that are also used by the Napari software, https://napari.org . In addition to the name strings listed below, shape can also be specified by a corresponding index in range 0-13.	
enum	cross, diamond, square, triangle up, star, clobber, disc, hbar, vbar, tailed arrow, triangle down, ring, x, arrow

MarkerFile

Description of settings and GUI objects for a marker dataset loaded from CSV file. Required properties are shown in bold text.		
type	object	
properties		
• title	Name of marker button	
	type	string
• comment	Optional description text shown next to marker button	
	type	string
	default	
• name	Name of marker tab	
	type	string
• autoLoad	If the CSV file for the marker dataset should be automatically loaded when the TMAP project is opened. If this is false, the user instead has to click on the marker button in the GUI to load the dataset.	
	type	boolean
	default	false
• hideSettings	Hide markers' settings and add a toggle button instead.	
	type	boolean
	default	false
• uid	A unique identifier used internally by TissUmaps to reference the marker dataset	
	type	string
• expectedHeader	ExpectedHeader	
• expectedRadios	ExpectedRadios	
• path	Relative file path to CSV file in which marker data is stored. If array of string, then a dropdown is created instead of a button.	
	type	string / array
• settings	type	array
	default	[]
	items	
	•	Setting

ExpectedHeader

Input field values for settings in a marker tab. Required properties are shown in bold text.		
type	object	
properties		
• X	Name of CSV column to use as X-coordinate	
	type	string
• Y	Name of CSV column to use as Y-coordinate	
	type	string
• gb_col	Name of CSV column to use as key to group markers by	
	type	string

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	default	null
• gb_name	Name of CSV column to display for groups instead of group key value	
	type	string
	default	null
• cb_cmap	Name of D3 color scale to be used for color mapping. See ColorScale for valid string values.	
	type	string
	default	
• cb_col	Name of CSV column containing scalar values for color mapping or hexadecimal RGB colors in format '#ff0000'	
	type	string
	default	null
• cb_gr_dict	JSON string specifying a custom dictionary for mapping group keys to group colors. Example: '{"key1": "#ff0000", "key2": "#00ff00", "key3": "#0000ff"}'	
	type	string
	default	
• scale_col	Name of CSV column containing scalar values for changing the size of markers	
	type	string
	default	null
• scale_factor	Numerical value for a fixed scale factor to be applied to markers	
	type	string
	default	1
• pie_col	Name of CSV column containing data for pie chart sectors. TissUMaps expects labels and numerical values for sectors to be separated by ':' characters in the CSV column data.	
	type	string
	default	null
• pie_dict	JSON string specifying a custom dictionary for mapping pie chart sector indices to colors. Example: '{0: "#ff0000", 1: "#00ff00", 2: "#0000ff"}'. If no dictionary is specified, TissUMaps will use a default color palette instead.	
	type	string
	default	
• shape_col	Name of CSV column containing a name or an index for marker shape. See also Shape .	
	type	string
	default	null
• shape_fixed	Name or index of a single fixed shape to be used for all markers. See Shape for valid string values.	
	type	string
	default	cross
• shape_gr_dict	JSON string specifying a custom dictionary for mapping group keys to group shapes. Example: '{"key1": "square", "key2": "diamond", "key3": "triangle up"}'. See also Shape .	
	type	string
	default	
• opacity_col	Name of CSV column containing scalar values for opacities	
	type	string
	default	null
• opacity	Numerical value for a fixed opacity factor to be applied to markers	

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• tooltip_fmt	type	<i>string</i>
	default	1
	Custom formatting string used for displaying metadata about a selected marker. See https://github.com/TissUMaps/TissUMaps/issues/2 for an overview of the grammar and keywords. If no string is specified, TissU-Maps will show default metadata depending on the context.	
	type	<i>string</i>
	default	

ExpectedRadios

Radio button state and checkbox state for settings in a marker tab. Required properties are shown in bold text.		
type	<i>object</i>	
properties		
• cb_col	If markers should be colored by data in CSV column	
	type	<i>boolean</i>
	default	false
• cb_gr	If markers should be colored by group	
	type	<i>boolean</i>
	default	true
• cb_gr_rand	If group color should be generated randomly	
	type	<i>boolean</i>
	default	false
• cb_gr_dict	If group color should be read from custom dictionary	
	type	<i>boolean</i>
	default	false
• cb_gr_key	If group color should be generated from group key	
	type	<i>boolean</i>
	default	true
• pie_check	If markers should be rendered as pie charts	
	type	<i>boolean</i>
	default	false
• scale_check	If markers should be scaled by data in CSV column	
	type	<i>boolean</i>
	default	false
• shape_col	If markers should get their shape from data in CSV column	
	type	<i>boolean</i>
	default	false
• shape_gr	If markers should get their shape from group	
	type	<i>boolean</i>
	default	true
• shape_gr_rand	If group shape should be generated randomly	
	type	<i>boolean</i>
	default	true
• shape_gr_dict	If group shape should be read from custom dictionary	
	type	<i>boolean</i>
	default	false
• shape_fixed	If a single fixed shape should be used for all markers	
	type	<i>boolean</i>
	default	false

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Table 3 – continued from previous page

• opacity_check	If markers should get their opacities from data in CSV column	
	type	<i>boolean</i>
	default	false
• _no_outline	If marker shapes should be rendered without outline	
	type	<i>boolean</i>
	default	false

RegionFile

Description of settings and regions loaded from GeoJSON file. Required properties are shown in bold text.		
type	object	
properties		
• title	Name of region button	
	type	string
• comment	Optional description text shown next to region button	
	type	string
	default	
• autoLoad	If the regions should be automatically loaded when the TMAP project is opened. If this is false, the user instead has to click on the region button in the GUI to load the regions.	
	type	boolean
	default	false
• path	Relative file path to GeoJSON file in which marker data is stored. If array of string, then a dropdown is created instead of a button.	
	type	string / array
• settings	type	array
	default	[]
	items	
	•	Setting

Setting

Advanced javascript setting, used to change the value of a property in a module, or to call a function in a module. If module.function is a function, then calls <code>module.function(value)</code> , else affects <code>value</code> to <code>module.function</code> . Required properties are shown in bold text.		
type	<i>object</i>	
properties		
• module	Module where the function or property lies.	
	type	<i>string</i>
• function	Function or property of the given module.	
	type	<i>string</i>
• value	type	<i>number</i>

4.4.2 Example of a .tmap file

```
{
  "filename": "TissUMaps_Example.tmap",
  "layers": [
    {
      "name": "Round1_A.tif",
      "tileSource": "images/Round1_A.tif.dzi"
    },
    {
      "name": "Round1_C.tif",
      "tileSource": "images/Round1_C.tif.dzi"
    }
  ],
  "layerOpacities": {
    "0": "1",
    "1": "1"
  },
  "layerVisibilities": {
    "0": true,
    "1": false,
  },
  "layerFilters": {
    "0": [
      {
        "name": "Color",
        "value": "0,100,0"
      }
    ],
    "1": [
      {
        "name": "Color",
        "value": "0,100,0"
      }
    ]
  },
  "filters": [
    "Color"
  ],
  "compositeMode": "lighter",
  "markerFiles": [
    {
      "autoLoad": false,
      "comment": "",
      "expectedHeader": {
        "X": "global_x",
        "Y": "global_y",
        "cb_cmap": "",
        "cb_col": "null",
        "cb_gr_dict": "",
        "gb_col": "Gene",
        "gb_name": "",
        "opacity": "1",

```

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```

        "opacity_col": "null",
        "pie_col": "null",
        "pie_dict": "",
        "scale_col": "null",
        "scale_factor": "0.5",
        "shape_col": "null",
        "shape_fixed": "cross",
        "shape_gr_dict": "",
        "tooltip_fmt": ""
    },
    "expectedRadios": {
        "cb_col": false,
        "cb_gr": true,
        "cb_gr_dict": false,
        "cb_gr_key": true,
        "cb_gr_rand": false,
        "pie_check": false,
        "scale_check": false,
        "shape_col": false,
        "shape_fixed": false,
        "shape_gr": true,
        "shape_gr_dict": false,
        "shape_gr_rand": true,
        "opacity_check": false
    },
    "name": " markers",
    "path": "./istdeco_codes_n.csv",
    "title": "Download markers",
    "uid": "uniquetab"
    }
],
"regions": {},
"plugins": [
    "Spot_Inspector"
],
"hideTabs": true,
"settings": []
}

```

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