



# High-throughput image processing with napari-ndev for the generalizable quantification of neurodevelopment.

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## Bridging the gap between the napari viewer and batch python scripting

- Accept diverse image formats, dimensionality, file size, and maintain key metadata.
- Allow advanced, arbitrary image processing workflows to be used by novice users.
- User-friendly sparse annotation and batch training of machine learning classifiers.
- Flexible label measurements, parsing of metadata, and summarization for easily readable datasets.

## Summary

Neurodevelopment exemplifies the diverse fields studying biological events from the subcellular to the organismal scale, each employing a wide range of microscopic techniques. Despite considerable recent progress in the python ecosystem towards large scale data analysis utilizing GPUs and artificial intelligence, non-coders still lack accessible tools for high-throughput and easily generalizable image analysis. To address this, we have developed napari-ndev (neuralDev) to bring together many useful python packages and bridge the gap between coding and GUI-based batch processing. We have also created python pipelines that automate the analysis of neural structure and morphology more efficiently than conventional manual or semi-automated approaches. We demonstrate the application of this segmentation and analysis pipeline across different scales of neurodevelopment, various microscopes and modalities, and a range of quantitative goals.

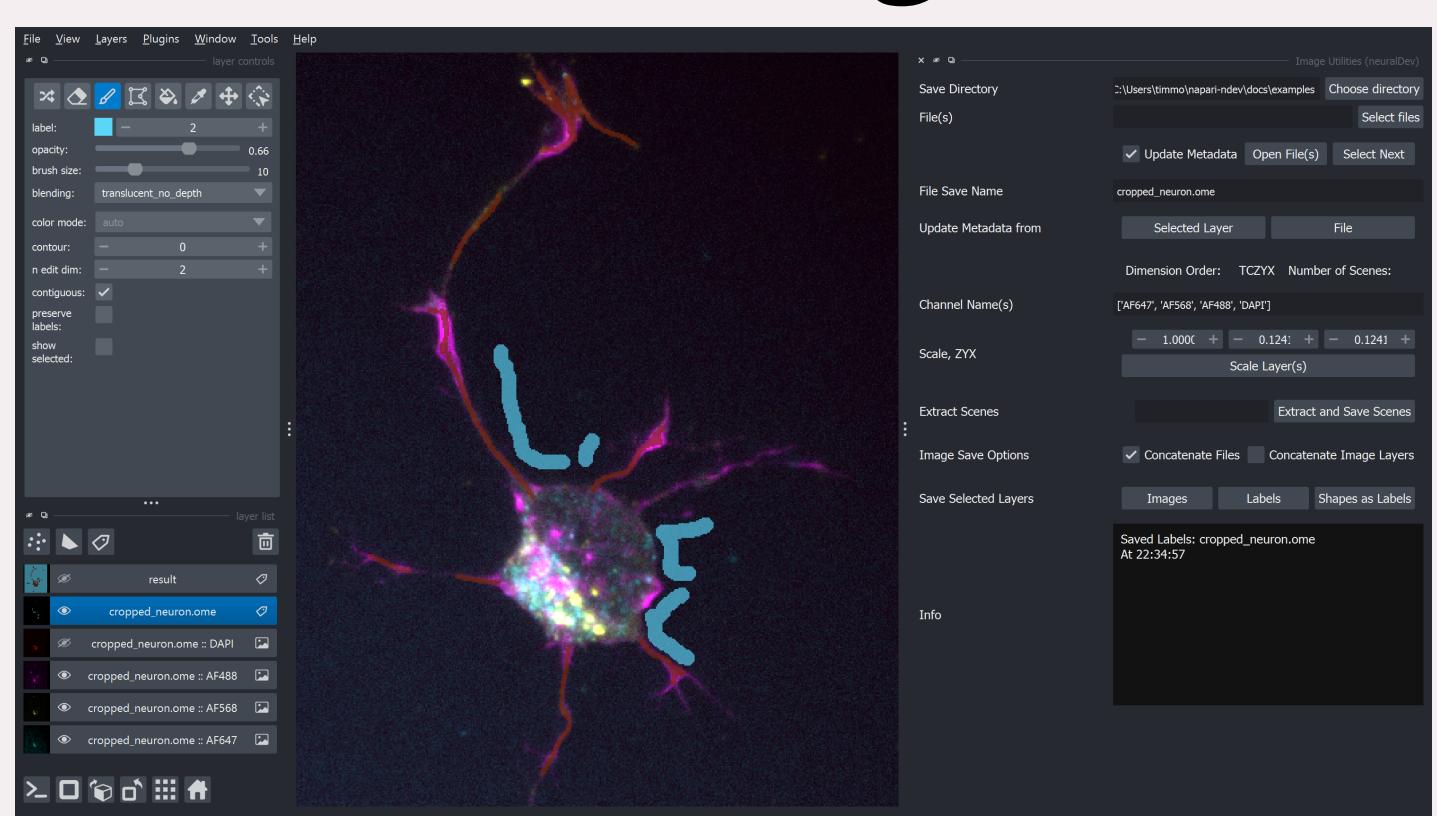
### neuralDev: Image Utilities

Uses

- Concatenate images
- Quickly draw and save Labels
- Utilize ROI-like Shape annotations consistently across files

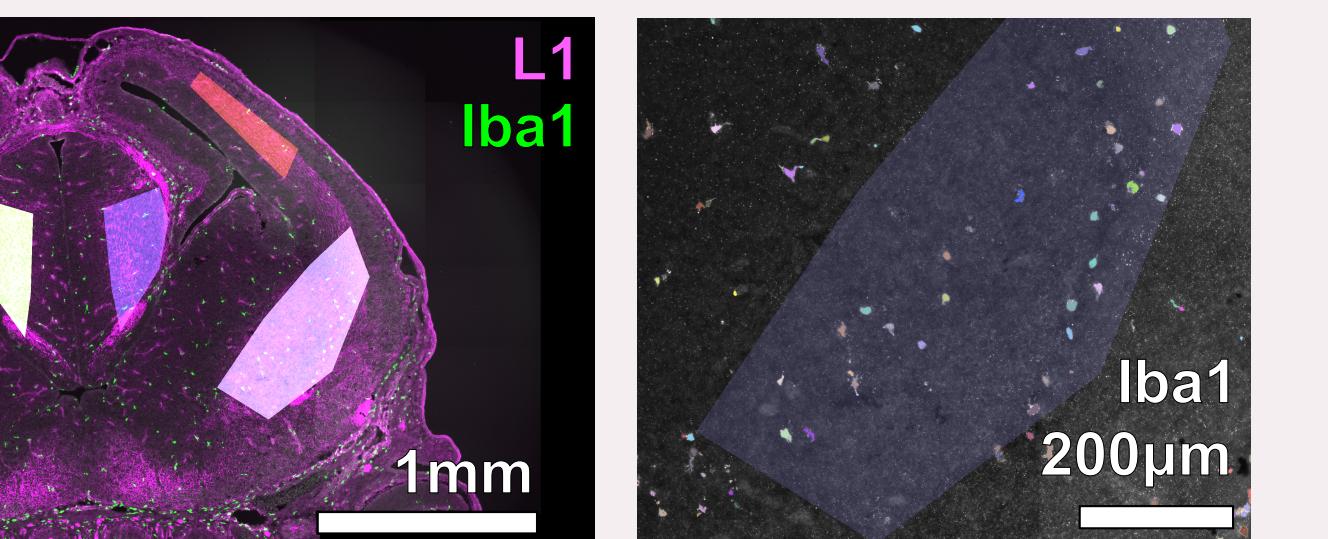
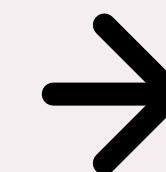
Diverse Formats

- Any of TCZYX dimensions
- RGB
- Multi-scene



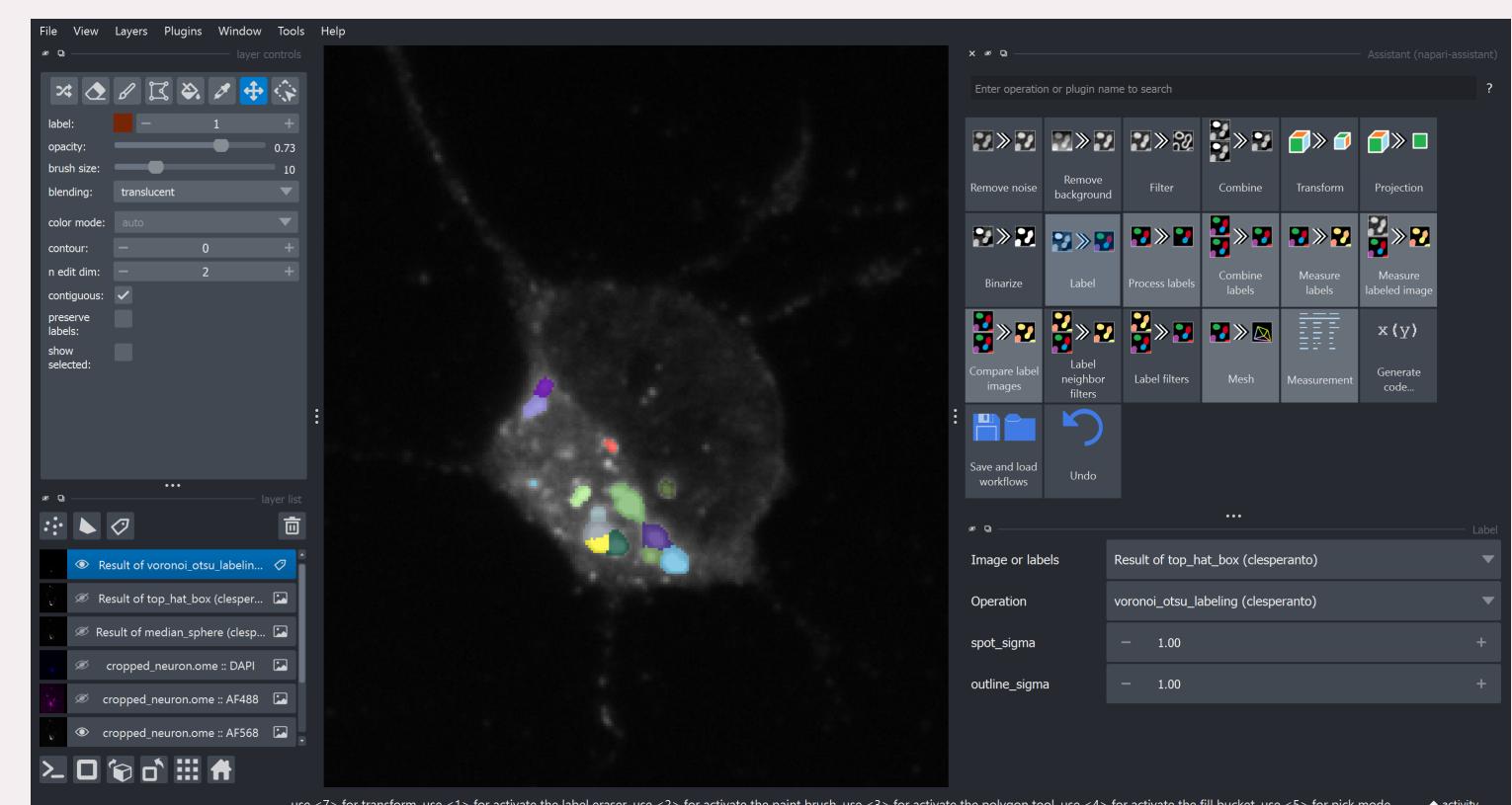
#### Preserve (or Fix) Metadata with OME-TIFF

- Convert to TCZYX
- Channel names
- Pixel scaling
- Keep scene and image identity intact
- Blind image names



Embryonic brain slice microglia segmentation with machine learning (AOPC Widget) better accommodates heterogeneity in sample intensity, quality, and background. Utilized Image Utilities to place identical ROIs across many different sections.

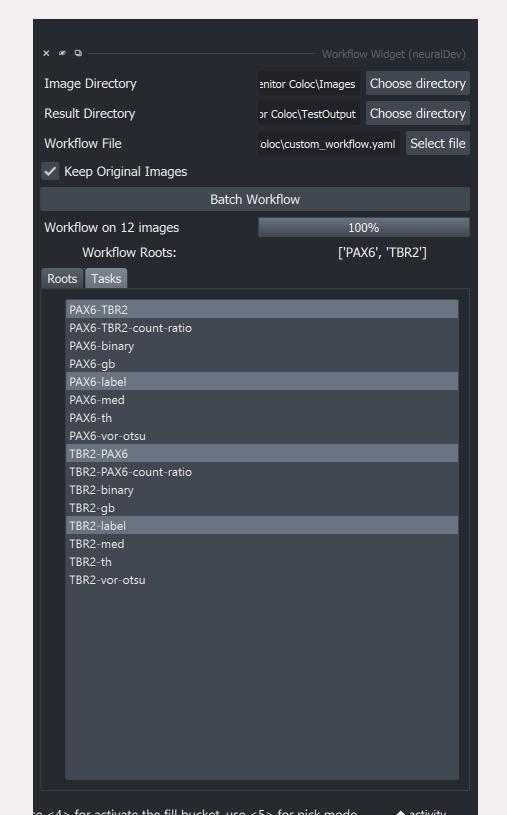
### napari-assistant



### neuralDev: Workflow Widget

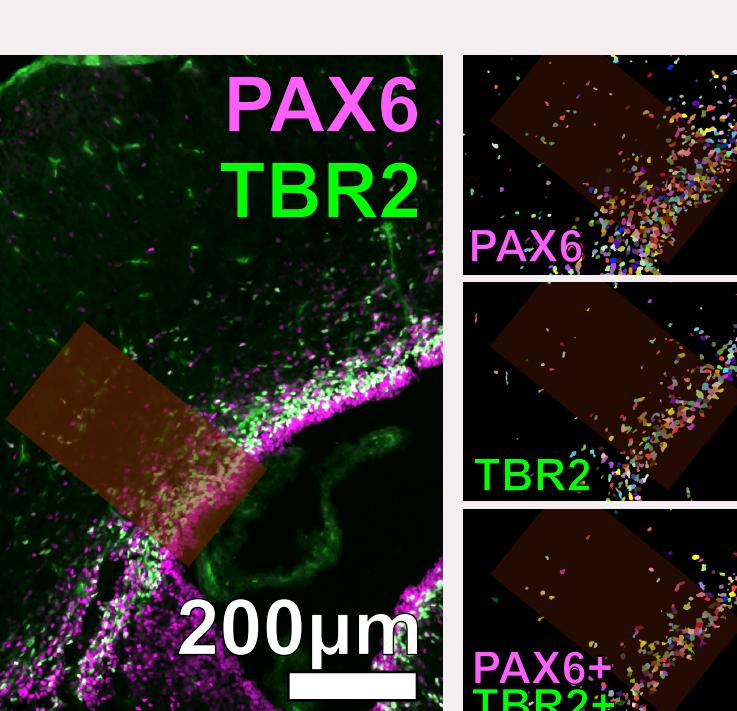
#### napari-workflows

- Export workflow file from napari-assistant
- Generate or modify workflows with scripting
- Allows experienced users to support novice users easily



#### Apply workflow in batch

- Select proper roots based on image metadata
- Choose to acquire any number of arbitrary tasks, not just terminal ones



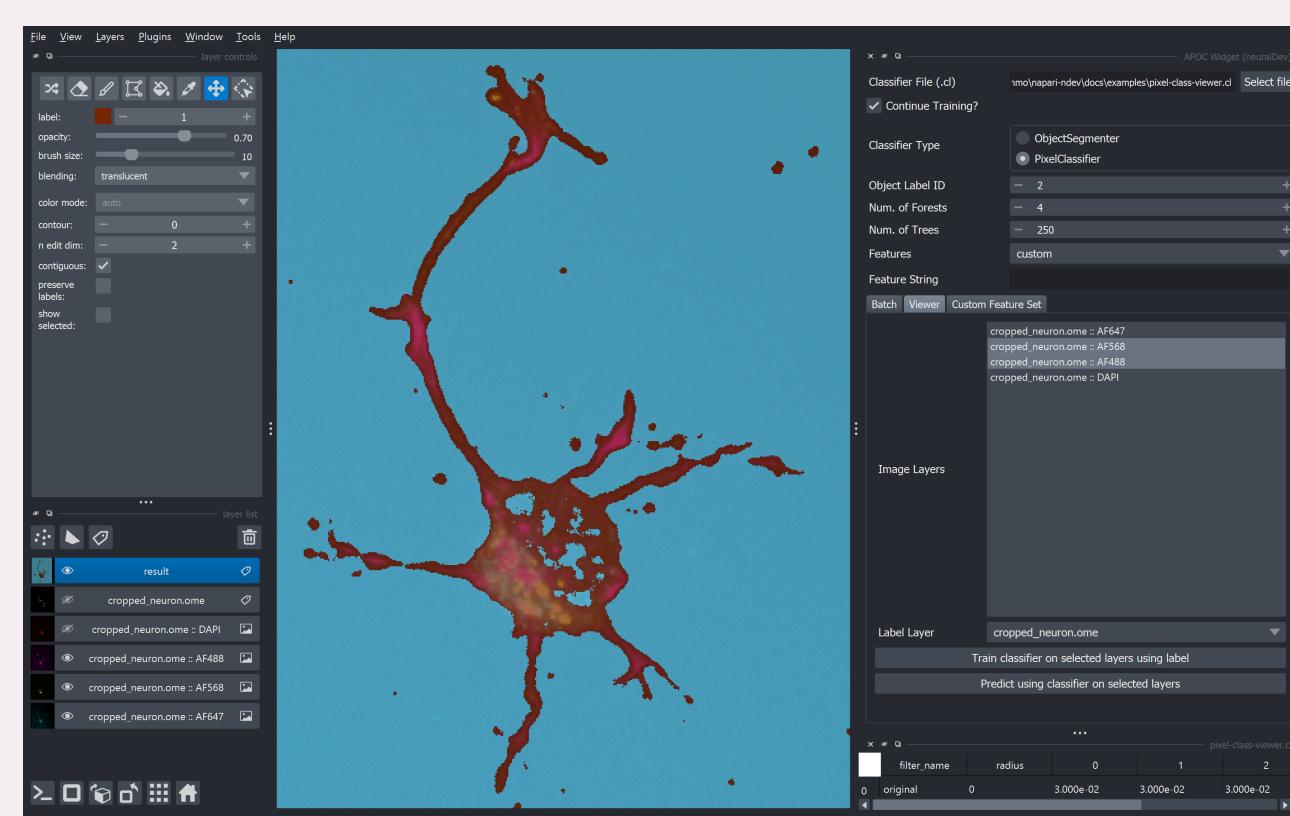
#### Embryonic brain section nuclei segmentation

generated with Image Utilities and Workflow Widget. Custom workflow edits allowed quick development of a co-occurrence pipeline.

### neuralDev: APOC Widget

#### 1. Generate and Visualize a Custom Classifier Feature Set

- Visually inspect features for usefulness, before training



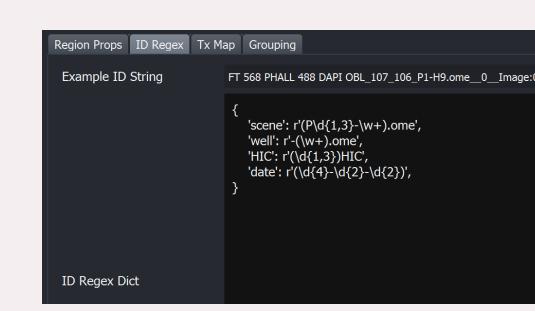
#### 3. Predict Using Classifier

- Both viewer and batch prediction
- Generate log files for reference of necessary parameters

### neuralDev: Measure Widget

#### 1. Measure properties of label objects

- Select label from a file, and optionally add intensity or region (ROI) images.
- Select properties to measure, and ensure scaling is correct.



#### 2. Extract metadata from filenames

- Map treatments of multi-well culture plates to an identifier

long format data, one object per row

	date	site	HC	well	scene	label	area	intensity	color	channel	media
2024-08-07	07/2024	24	4H	P1-H9	2	0.246413	0	9.100M DF NCM	0	100uM DDF	18.801841
2024-08-07	07/2024	24	4H	P1-H9	3	3.03613	0	9.100M DF NCM	0	100uM DDF	12.103688
2024-08-07	07/2024	24	4H	P1-H9	4	3.036079	0	9.100M DF NCM	0	100uM DDF	12.103688
2024-08-07	07/2024	24	4H	P1-H9	5	269.2832	1	9.100M DF NCM	0	100uM DDF	30.579038
2024-08-07	07/2024	24	4H	P1-H9	6	1.386073	0	9.100M DF NCM	0	100uM DDF	1.297.4512
2024-08-07	07/2024	24	4H	P1-H9	7	1.386073	0	9.100M DF NCM	0	100uM DDF	1.297.4512
2024-08-07	07/2024	24	4H	P1-H9	8	0.030862	0	9.100M DF NCM	0	100uM DDF	12.854194
2024-08-07	07/2024	24	4H	P1-H9	9	0.030862	0	9.100M DF NCM	0	100uM DDF	12.854194
2024-08-07	07/2024	24	4H	P1-H9	10	0.194861	0	9.100M DF NCM	0	100uM DDF	2.446.7621
2024-08-07	07/2024	24	4H	P1-H9	11	0.050576	0	9.100M DF NCM	0	100uM DDF	2.446.7621
2024-08-07	07/2024	24	4H	P1-H9	12	0.050576	0	9.100M DF NCM	0	100uM DDF	2.446.7621

#### 4. Summarize data

- Group by identifiers to summarize, at minimum, the count of objects for each group.
- Use intensity images, such as the value of an ROI or object class, to group data.
- Choose functions for aggregating grouped data

	date	site	HC	well	scene	intensity	color	channel	media
2024-08-07	07/2024	24	4H	P1-H9	2	0.246413	0	100uM DDF	18.801841
2024-08-07	07/2024	24	4H	P1-H9	3	3.03613	0	100uM DDF	12.103688
2024-08-07	07/2024	24	4H	P1-H9	4	3.036079	0	100uM DDF	12.103688
2024-08-07	07/2024	24	4H	P1-H9	5	269.2832	1	100uM DDF	30.579038
2024-08-07	07/2024	24	4H	P1-H9	6	1.386073	0	100uM DDF	1.297.4512
2024-08-07	07/2024	24	4H	P1-H9	7	1.386073	0	100uM DDF	1.297.4512
2024-08-07	07/2024	24	4H	P1-H9	8	0.030862	0	100uM DDF	12.854194
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2024-08-07	07/2024	24	4H	P1-H9	10	0.194861	0	100uM DDF	2.446.7621
2024-08-07	07/2024	24	4H	P1-H9	11	0.050576	0	100uM DDF	2.446.7621
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#### summarized data

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2024-08-07	07/2024	24	4H	P1-H9	2	0.246413	0	100uM DDF	18.801841
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