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Scalable automated (synapse) detection using the Open Connectome Project

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Background

- New neuroimaging datasets are large (10GB to 100TB+)
- Object detection is a canonical problem
- Many techniques exist to aid in scene parsing

Challenge

- Translating algorithms for neuroscience discovery is multi-faceted and complex
- Solving these issues often requires re-solving common problems
- A reusable framework would facilitate scientists doing science

Action

- We developed a flexible analytics toolbox to enable rapid discovery
- These tools are built into the NeuroData framework
- Algorithms include a variety of community-developed and custom tools for common workflows

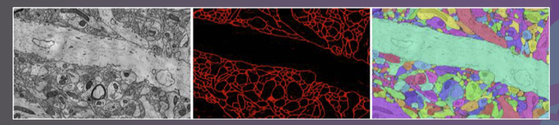
Resolution

- Our code was used for object detection tasks across multiple modalities, including Array Tomography, X-Ray Microscopy and Electron Microscopy
- Code, data, and an analytics stack are available at **neurodata.io**

Background

NeuroData provides an ecosystem of tools and services to enable data sharing and computation:

- High-throughput reads/writes to spatial database to support high performance computing (HPC)
- Spatially co-registered image and annotation data
- Flexible, interoperable RAMON data standard to enable both annotations and metadata
- RESTful endpoints, with MATLAB and Python interfaces for rapid workflow construction



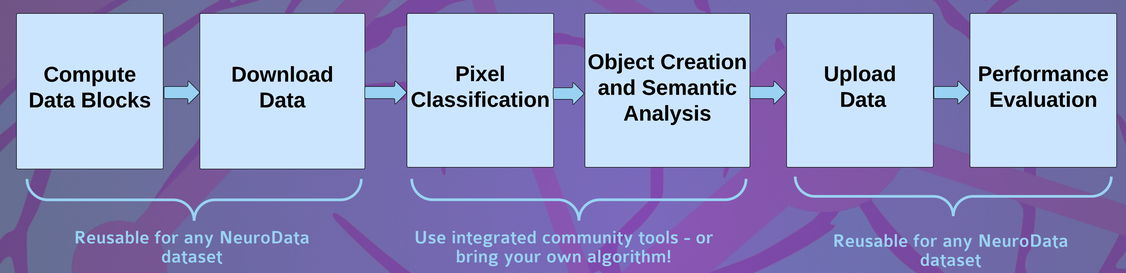
Challenge

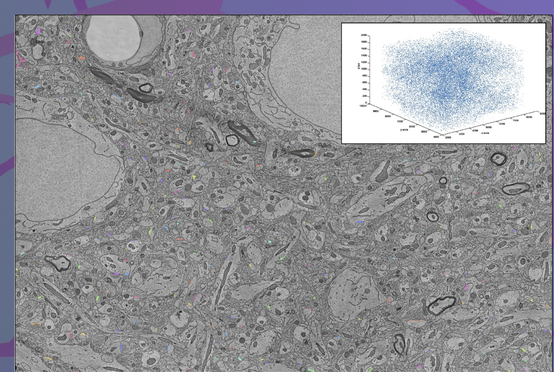
Processing neuroscience data at scale requires addressing a wide range of challenges, including:

- Data storage
- Data access
- Algorithm Implementation
- Algorithm scaling
- Utilizing computational resources
- Enabling reproducible science
- Multiscale scene understanding
- Recording object metadata
- Performance Assessment

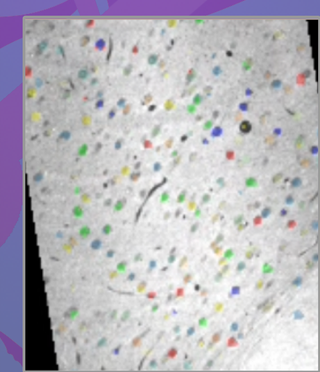
Action

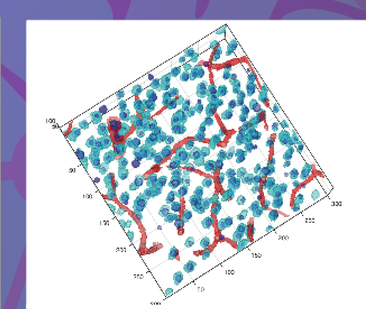
Prototype Object Detection Workflow



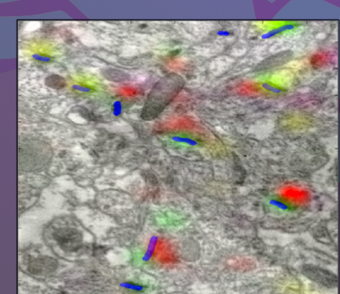


Visualization of large scale synapse detection results; we found a total of 50,000 putative synapses in our volume. An XY slice showing detected synapses is shown, and a point cloud of the synapse centroids are also visualized (inset).

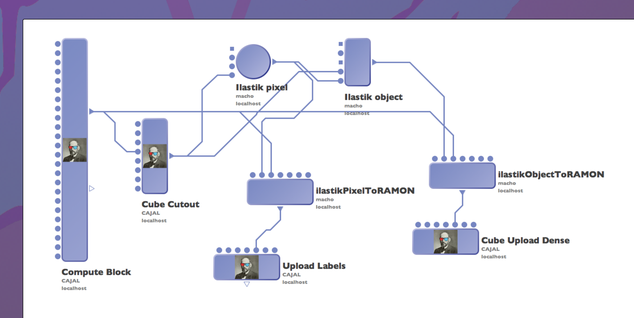




X-Ray Microscopy raw cell detections at scale (left). Manually segmented vessels (red) and cell bodies (cyan). Detected cell bodies are shown in blue.



Array Tomography IF Data - EM slice (in grayscale) with IF channels overlaid: PSD-95 (green), synapsin (red), VGluT1 (pink), NR1 (yellow). The synaptic clefts (putative ground truth) are highlighted in blue. A prototype classifier has been developed and tested using the methods described here.



Example LONI workflow, demonstrating the process for object detection using Ilasik, a multipurpose machine learning tool (ilastik.org)

Resolution

- Code and data are open and available at **neurodata.io**
- NeuroDataVision exists as an integrated analytics stack in an Amazon Machine Image for mesoscale processing and prototyping
- Many algorithms have been included for immediate use; the framework can be easily extended
- More complex workflows (e.g., graph estimation from images) are also available

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