Computer Vision Laboratory (CVLAB)

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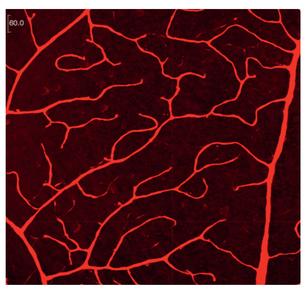
Interactive Learning for Biomedical Image Analysis

MOTIVATION

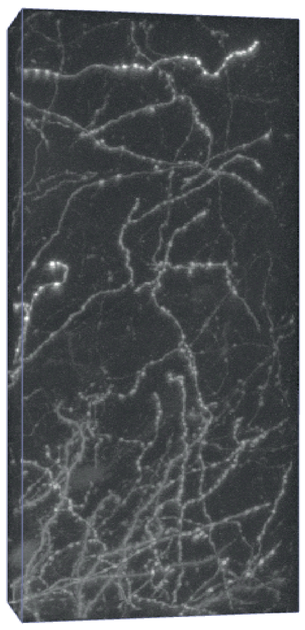
Increase in the amount and quality of biomedical imaging data gives us hope to unravel some of the greatest science challenges such as treatment of neurodegenerative diseases or understanding the working principles of human brain.

However, there exist certain challenges including:
- size and variability of data
- imaging artifacts
- annotation effort



Blood vessels

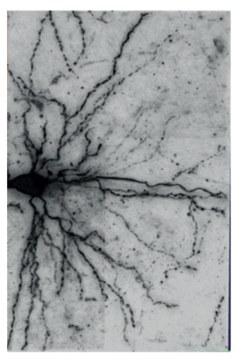
Single neuron



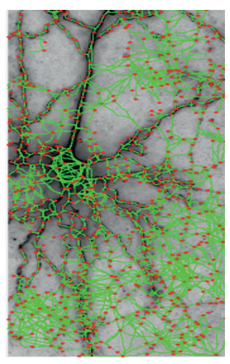
Network of neurons

RECONSTRUCTION OF LINEAR STRUCTURES

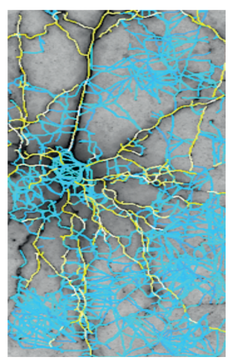
Our automated algorithm finds the underlying **graph representation** of the linear network. This allows neuroscientists to study **brain connectivity** and its **electrical properties**.



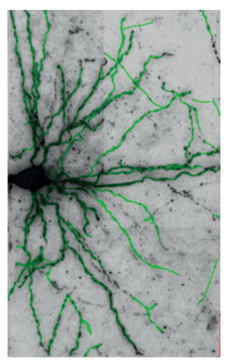
Input image



Overcomplete graph



Weighted graph

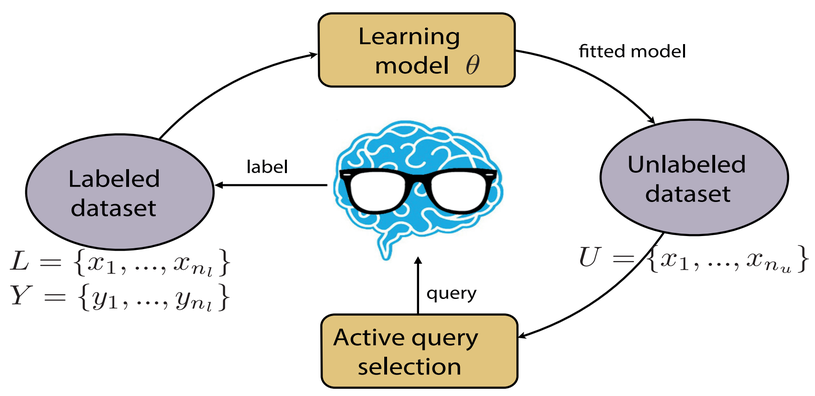


Final reconstruction

Thanks to its efficient formulation we can deal even with very large graphs.

INTERACTIVE LEARNING

Goal: obtain a reliable reconstruction with the least amount of user interaction. This includes both collecting training data (**Active Learning**) and postprocessing (**proofreading**).

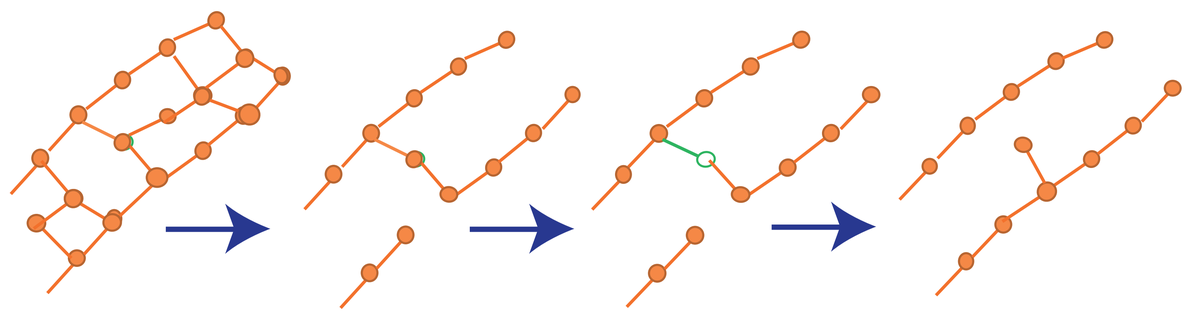


Problem: find the set of the most informative unlabelled samples and obtain their labels to improve the model.

EXPLOITING GEOMETRY

Traditional AL techniques do not take into account the **very specific geometry of curvilinear structures.** We propose an approach that exploits global topology information and can be used both in AL and proofreading settings.

General idea: Edges for which "flipping" predicted label improves the reconstruction are probable mistakes and require feedback from the user.



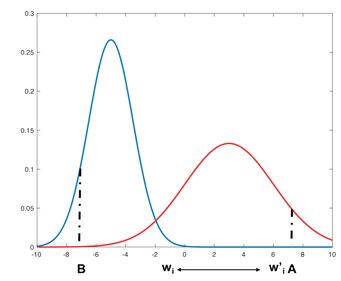
Overcomplete graph — *Initial reconstruction R** — *Change weight* — *Initial reconstruction R'*

Reconstruction improvement: measured by the cost change

$$\Delta c = c(R^*) - c(R')$$

Weight transformation:

$$w'_i = \begin{cases} A + w_i & if\ w_i < 0 \\ B + w_i & if\ w_i > 0 \end{cases}$$



Proofreading: some of the mistakes may not be crucial for the reconstruction; introduce additional term to make sure that only edges relevant for the geometry are selected:

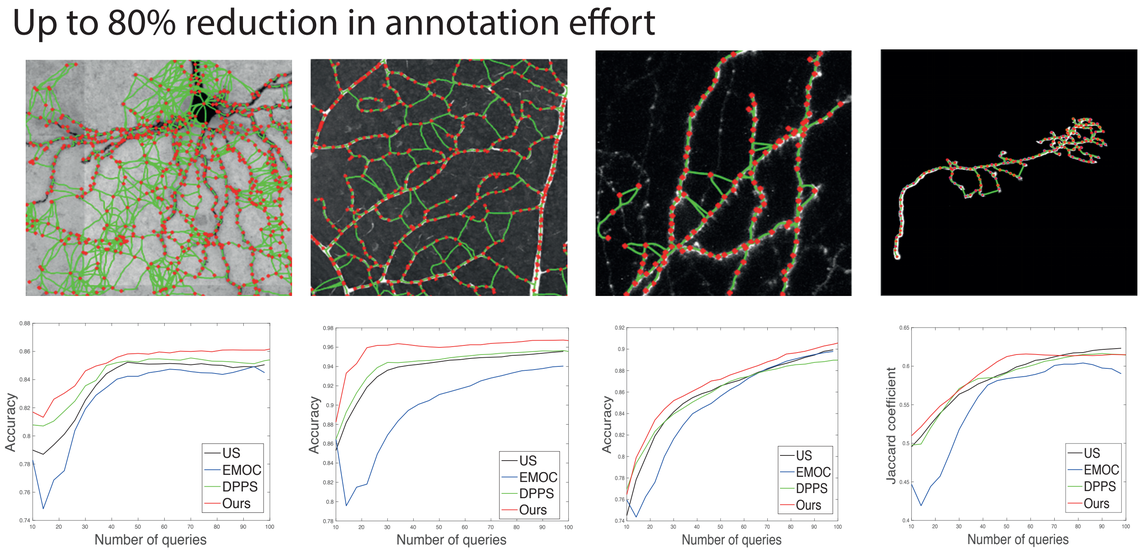
$$s_i = \frac{c(R^*) - c(R')}{DIADEM(R^*, R')}$$

DIADEM score measures topological similarity between two reconstructions.

RESULTS

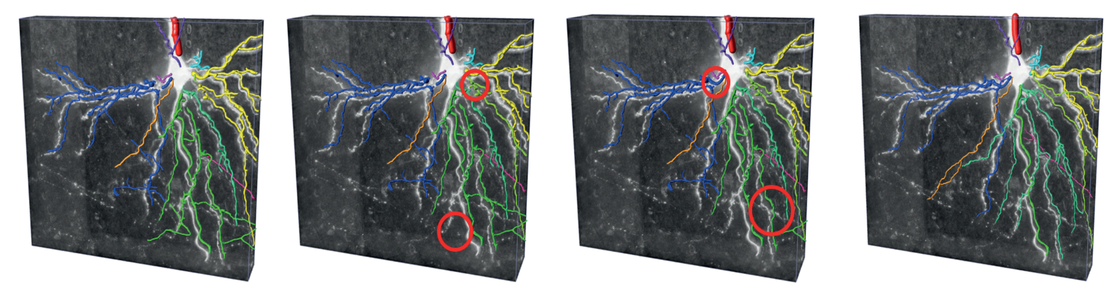
Active Learning

Up to 80% reduction in annotation effort



Focused Proofreading

50 samples to train classifier and 25 for proofreading



Initial reconstruction — *After 10 corrections* — *After 25 corrections* — *Ground-truth*

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