Dendrite Delineation

Brightfield Stack, Automated delineation

Delineating Dendritic Trees

Processing steps:
1. Compute the dendriteness of individual voxels.
2. Select voxels that locally maximize this measure.
3. Build a tubular graph by linking these voxels.
4. Find an optimal tree within the graph.

4D Tubularity Measure

- Compute features in scale space using a variant of the Oriented Flux and antisymmetry operators.
- Find local maxima in both position and width.

Building the Tubular Graph

Given the samples, the paths are computed as 4D geodesics:

\[ p_{ij} = \arg\min_{\gamma} \int_0^L \mathcal{P}(\gamma(s)) \, ds, \]

\(-\) Can handle very irregular tubes.

Turetken et al. CVPR'12

Benmansour & Cohen, IJCV'10
Minimum Arborescence Problem

\[ t^* = \arg\max_{t \in T(G)} P(T = t | I) \]

\[ = \arg\max_{t \in T(G)} P(I | T = t) P(T = t) \]

\[ = \arg\min_{t \in T(G)} \sum_{e_{ij} \in G} c_{ij} t_{ij} \]

\[ t_{ij} \in \{0, 1\} \]

given the root note \( v_r \).

Brightfield

From Trees to Graph

Even in true tree structures, some vertices might have to be shared:

- Allow loops
- Penalize hanging branches.

Still a QMIP problem.

QMIP Formulation

\[ \min \sum_{e_{ij} \in E, e_{jk} \in E} c_{ijk} t_{ij} t_{jk} \]

s.t.

\[ \sum_{v_j \in V \setminus \{v_r\}} y_{ij} \leq 1, \quad \forall v_j \in V \setminus \{v_r\}, \]

\[ \sum_{v_j \in V \setminus \{v_k\}} y_{jk} \leq 1, \quad \forall v_k \in V \setminus \{v_r\}, \]

\[ \sum_{v_j \in V \setminus \{v_k\}} y_{ij} - \sum_{v_j \in V \setminus \{v_k\}} y_{ji} = 1, \quad \forall v_k \in V \setminus \{v_r, v_k\}, \]

\[ y_{ij} \geq 0, \quad \forall e_{ij} \in E, \quad v_i \in V \setminus \{v_r, v_j\}, \]

\[ t_{ij} \in \{0, 1\}, \quad \forall e_{ij} \in E. \]
Brightfield Stack
Ground Truth
QMIP reconstruction

Brainbow Stack
Ground Truth
QMIP reconstruction

Evolving Structures
• Three Two-photon image stacks taken a week apart in-vivo.
• Simultaneous reconstruction in all three stacks.
  —> Automated change detection + More robust delineation.

 Courtesy of J. Lichtman

 Courtesy of A. Holtmaat