High-Level Sprout Geometry Extraction and Analysis of In Vitro Angiogenesis

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Overview

**Figure:** Before

**Spreadsheet Report**

<table>
<thead>
<tr>
<th>Sprout Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Branching Factor**

**Figure:** After
1. Motivation
2. Fibrin Gel Bead Sprouting Assay (FGBSA)
3. Methodology
4. Results
Solid tumors have an avascular (no nearby blood vessels) growth phase that allows for an approximate maximum size of 1-2mm in diameter\(^1\).

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Think of the size of *very coarse sand*.

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Tumor angiogenesis enables relentless tumor growth and metastasis.

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Current Methodology

1. Sprout Restoration
2. Sholl Analysis
Current Methodology

1. Edge Detection and Polygon Approximation
2. Bead Detection (Hough Transform)
3. Non-Sprout Detection
4. Dilation for Approximate Centerline
5. Thinning and Pruning
6. **Sholl Analysis**

Expanded sprout restoration methods
High-Level Sprout Geometry Extraction and Analysis of In Vitro Angiogenesis
Edge Detection and Polygon Approximation
Dilation for Approximate Centerline

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High-Level Sprout Geometry Extraction and Analysis of In Vitro Angiogenesis
Thinning and Pruning

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Sholl Analysis: Why

No tracing required
Morphometric descriptors can be obtained

Figure: D. A. Sholl. Dendritic organization in the neurons of the visual and motor cortices of the cat. *J Anat.*, 87(4):387406, 1953.
Sholl Analysis: Implementation
Sholl Analysis: Bresenham Circle Algorithm
Sholl Analysis: Unordered Property of Circle Algorithm

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Sholl Analysis: Ordered Bresenham Circle Algorithm

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Sholl Analysis: Concentric Circles Analysis
Important descriptors

1. Sprout enumeration
2. Average sprout length
3. Branching factor (Shoenen Ramification Index)
4. Critical Value
High-Level Sprout Geometry Extraction and Analysis of In Vitro Angiogenesis
Problem 1 Non-continuous sprouts
Problem 2 Bad initial radius
Solution Bounded crossings integration
- Mean of $n$ crossings
- Median of $n$ crossings

Figure: Crossing integration over intervals of size 3
Results

Resulting sprout counts are compared with an expert observer using 15 images.

\[
\text{RMSE} = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (\hat{Y}_i - Y_i)^2}
\]  

(1)

<table>
<thead>
<tr>
<th>Method Variant</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Integration Method</td>
<td>1.736</td>
</tr>
<tr>
<td>Ignoring isolated points</td>
<td>1.79</td>
</tr>
<tr>
<td>Mean Integration Method Benchmark</td>
<td>1.93</td>
</tr>
<tr>
<td>LIS on Large Image</td>
<td>3.45</td>
</tr>
</tbody>
</table>

**Table:** Results of Method Variants
Further Work

1. Gather results for median integration method
2. Distinguish individual sprouts
4. Three-dimensional reconstruction using multiple image depths
Thank you. Questions?