Hybrid parallelization of a seeded region growing segmentation of brain images for a GPU cluster

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The introduction of novel technologies always carries new challenges regarding the processing of data.

- Newly developed imaging technique: Polarized Light Imaging
- Reconstructing hundreds of terabytes of image data
- Image segmentation as a preprocessing step: masking of brain and non-brain regions
- Parallelization of the segmentation for a GPU cluster

### Polarized Light Imaging
- Development at the Institute for Neuroscience and Medicine (INM-1), Forschungszentrum Jülich
- Aim: extracting the course of single nerve fibers
- Sections of postmortem human brain tissue, each 70 µm thick
- Imaging of the sections under linearly polarized light with varying polarization

#### Automated Choice of Seeds
- Brain tissue on a bright background
- Including artifacts and image noise
- Joint intensity histogram of all tiles
- Threshold between brain and background intensities defined by user → single point of interaction per brain
- Measure $m_{\text{cand}}$ for every intensity interval

\[ m_{\text{cand}}(x,y) = \max \left( \frac{g(x,y) - q_0}{q_1 - q_0}, q_0 \right) \]

- Linear smoothing of $m_{\text{cand}}$ to minimize the influence of image noise

\[ m_{\text{final}}(x,y) = \sum_{i=-m}^{m} \sum_{k=-n}^{n} w(i,k) \cdot m_{\text{cand}}(x+i,y+k) \]

- Removing dirt particles in the background marked as seeds

#### Multi-Core Parallelization
- Neighboring tiles: overlapping of ~ 30% → independent processing
- Tiles equally distributed between the processes

### GPU Parallelization
- Automated choice of seeds consists of data parallel steps
- GPUs take advantage of data parallelism → CUDA
- One-to-one assignment of pixels to CUDA threads

#### Additional GPU accelerates the segmentation by a factor of 20

<table>
<thead>
<tr>
<th>#CPUs</th>
<th>#GPUs</th>
<th>Runtime/Brain</th>
</tr>
</thead>
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<td>295 days</td>
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<tr>
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</tr>
<tr>
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<td>4.6 days</td>
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<tr>
<td>64</td>
<td>64</td>
<td>5.6 hours</td>
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</tbody>
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