Automatic Selection of Mask and Arterial Phase Images for Temporally-Resolved MR Digital Subtraction Angiography

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Weil Medical College of Cornell University
2D Projection MRA: 5 ml Gd

Coronal T1

Raw image

Complex subtraction

Left

Right
2D Projection MRA: + complex subtraction

Ankles

Knee
Time-resolved background-subtracted CEMRA

- Time-resolved image gives too many images
- Surgeon prefers one image that shows everything
- Our goal: Create a single best subtraction image by combining best mask and best arterial phase images
Coronal spoiled gradient echo sequence parameters

- TR/TE/flip angle = 10/2/60 degrees
- Slab thickness = 7-10 cm
- Field-of-view = 30cm
- Matrix = 256x192
- Bandwidth = 16 kHz
- The imaging time
  - 1.95 seconds per acquisition
  - repeat the acquisition 35 times
  - total of 67 seconds
Major challenges

- Identify the contrast bolus arrival
- Avoid motion corrupted images
- Tedious manual procedure
**Major challenges**

- Identify the contrast bolus arrival
- Avoid motion corrupted images
- Tedious manual procedure
- Issues
  - Quantify “image quality”
  - Select the mask and arterial phase images based on image quality
Subtracted Image Quality Evaluation

- Two basic criteria
  - Bright foreground (i.e. artery)
  - Dark background

- Quality = avg(Artery) – avg(Background)

- Problem: How to determine whether each pixel is in artery or background

- We need assumptions!
  - Artery is thin and vertically oriented
  - Artery width is typically 1-5 mm
Artery-Background Classification
Artery-Background Classification

- A pixel is in the artery
  - If the pixel ranks in brightness between 1\textsuperscript{st} and 2\textsuperscript{nd} of 128 pixels in the scan line.

- A pixel is in the background
  - If the pixel ranks in brightness between 11\textsuperscript{th} and 128\textsuperscript{th} of 128 pixels in the scan line.

- Unclassified
  - Otherwise
Select mask and arterial phase

Contrast arrival detection

Best mask / arterial phase pair selection

Best mask set / arterial phase set selection
Contrast Arrival Detection

Time=9, Quality=18.78
<table>
<thead>
<tr>
<th>masks 5</th>
<th>arterial 1</th>
<th>arterial 2</th>
<th>arterial 3</th>
<th>arterial 4</th>
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## Best mask set / arterial phase set selection

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Patients

- Period: Sep 11, 2000 to Nov 25, 2000
- Demography
  - 26 males aged 24 – 87 (mean 70) years
  - 19 females aged 33 – 85 (mean 68) years.
- The primary indications
  - claudication (n=23)
  - limb threatening ischemia (n=11)
  - aneurysm (n=7)
  - post-bypass graft (n=3)
  - dissection (n=1).
- Approved by our Institutional Review Board.
Image evaluation

- Blind test by two radiologists (MRP, HE)
  - Auto >> Manual
  - Auto > Manual
  - Auto ≅ Manual
  - Auto < Manual
  - Auto << Manual

- Statistical analysis
  - Paired signed-rank Wilcoxon test
## Image Quality Comparison

<table>
<thead>
<tr>
<th></th>
<th>Radiologist 1</th>
<th>Radiologist 2</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Auto &gt;&gt; Manual</td>
<td>3</td>
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<td>6</td>
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<tr>
<td>Auto &gt; Manual</td>
<td>25</td>
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<td>36</td>
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<tr>
<td>Auto ≈ Manual</td>
<td>2</td>
<td>9</td>
<td>11</td>
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<tr>
<td>Auto &lt; Manual</td>
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<tr>
<td>Auto &lt;&lt; Manual</td>
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<td><strong>p value</strong></td>
<td>0.1533</td>
<td>0.2043</td>
<td>0.9081</td>
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Automatic wins

Automatic

Better geniculate arteries

Manual

Auto > Manual (both readers)
Automatic wins

Automatic

Manual

More details of distal arteries but more background veins in the left leg

Auto > Manual (reader 1) and Auto >> Manual (reader 2)
<table>
<thead>
<tr>
<th></th>
<th>Automatic</th>
<th>Manual</th>
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<tbody>
<tr>
<td>Trade-off</td>
<td>Reduction in background motion artifacts</td>
<td>More details in distal left leg</td>
</tr>
<tr>
<td></td>
<td>Auto &lt; Manual (both readers)</td>
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</table>
Trade-off

Automatic

Manual

More details of distal arteries but more background veins in the left leg

Slightly better proximal arteries

Auto < Manual (reader 1) and Auto ≅ Manual (reader 2)
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Trade-off

**Automatic**

Better distal tibial arteries and the right popliteal artery

**Manual**

Better detail of the left popliteal artery

Auto > Manual (reader 1) and Auto \(\cong\) Manual (reader 2)
Manual wins

Enhanced bony structure

Auto << Manual (both readers)
Contribution

- Automatic image post-processing technique
  - Simple yet effective
  - Daily use
  - PC version coming soon!

Special thanks to

- Younga Kim: Slide preparation
- All of you
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