EVALUATION OF ARTERY VISUALIZATIONS FOR HEART DISEASE DIAGNOSIS

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EVALUATION OF ARTERY VISUALIZATIONS FOR HEART DISEASE DIAGNOSIS
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**NON-INVASIVE DIAGNOSIS**

1. Obtain patient CT data
2. Segment arteries
3. Generate patient geometries
4. Patient specific blood flow simulation
5. Visualize and analyze data
6. Clinical decision
DATA

**initial disease**

ESS = endothelial shear stress  
(i.e., frictional force from blood flow)

This can rupture and give you a heart attack!
Low ESS = BAD

Initial disease

Plaque

ESS = endothelial shear stress
(i.e., frictional force from blood flow)

very low ESS

This can rupture and give you a heart attack!

cannot directly measure ESS in living patients!
PREVIOUS WORK

- ESS Vessel Visualization

[Rybicki, et al. 2009]  [Chatzizisis, et al. 2007]
PREVIOUS WORK

- 2D vs. 3D Evaluation
  [e.g., Cockburn & McKenzie (2002), Laidlaw, et al. (2005), Troy, et al. (2007), Forsberg et al. (2009)]

• Color Map Evaluation
  
  [e.g., Ware (1988), Rheingans (1992), Rogowitz & Kalvin (2001), Kindlmann, et al. (2002)]
FORMATIVE QUALITATIVE STUDY

- Semi-structured interviews
- 10 medical doctors and researchers
- Brigham & Women’s Hospital (Boston, MA)
3D
LAYOUT AND PROJECTIONS
COLOR
COLOR

Preferred (standard)

Too “radiological”

Non-rainbow favorite!
Quantitative Study: Goals

3D vs. 2D

Rainbow vs. diverging
QUANTITATIVE STUDY

- 21 Harvard Medical students (12 women and 9 men)
- Mixed within-subject and between-subject design:
  - *within* = dimensionality of representation (2D or 3D)
  - *between* = color mapping (rainbow or diverging)

Example diagrams for participants A and B.
Quantitative Study

• Dependent measures:
  ‣ fraction of low ESS regions identified
  ‣ number of false positives (i.e., non-low ESS regions identified as low ESS)
  ‣ time to complete a diagnosis
QUANTITATIVE STUDY
QUANTITATIVE STUDY
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QUANTITATIVE STUDY
RESULTS
Strong effect of **dimensionality** on accuracy

39%  How many low ESS regions found?  62%
Strong effect of dimensionality on accuracy
...as well as color

39%  How many low ESS regions found?  91%
EFFICIENCY

Participants more efficient in 2D.

5.6 sec/region

2.4 sec/region
EFFICIENCY

Participants more **efficient** in **2D**.
Rainbow color map has greater effect on efficiency in **3D**.

10.2 sec/region

2.6 sec/region
COMPLEXITY

Accuracy decreases with increased data complexity in 3D

participants less accurate
COMPLEXITY

Accuracy decreases with increased data complexity in 3D

(not true in 2D!)
<table>
<thead>
<tr>
<th>Subjective Responses</th>
<th>2D</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found it easy to identify low ESS regions.</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>I was able to perform the task efficiently.</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>I am confident I found all the low ESS regions.</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>I am confident all the places I marked are really low ESS.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Domain experts important for design and evaluation

• Even for 3D spatial data, a 2D representation is
  ‣ more accurate for spatial tasks
  ‣ more efficient for spatial tasks

• Rainbow color map
  ‣ is not accurate and not efficient
  ‣ has adverse effects even greater in 3D
CONCLUDING REMARKS

• 3D representation is still essential for surgical planning

• 2D tree diagram applicable to other applications

• Quantitative study convinced our users of good visualization practices
FOR MORE INFORMATION...

On this paper/project: http://bit.ly/hemovis

On my other research: http://bit.ly/mborkin

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