EVALUATION OF ARTERY VISUALIZATIONS FOR HEART DISEASE DIAGNOSIS

Michelle Borkin,
Krzysztof Gajos, Amanda Peters, Dimitrios Mitsouras,
Simone Melchionna, Frank Rybicki, Charles Feldman,
and Hanspeter Pfister

Harvard School of Engineering & Applied Sciences
Harvard Medical School
Brigham & Women’s Hospital
**NON-INVASIVE DIAGNOSIS**

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

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

This can rupture and give you a heart attack!
**DATA**

Low ESS = **BAD**

This can rupture and give you a heart attack!

**cannot directly measure ESS in living patients!**

ESS = endothelial shear stress
(i.e., frictional force from blood flow)
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), Tory, et al. (2007), Forsberg et al. (2009)]
FORMATIVE QUALITATIVE STUDY

- Semi-structured interviews
- 10 medical doctors and researchers
- Brigham & Women’s Hospital (Boston, MA)

Clinical decision \[\rightarrow\] Visualize and analyze data
LAYOUT AND PROJECTIONS
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)

e.g., Participant A
e.g., Participant 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
RESULTS
ACCURACY

Strong effect of **dimensionality** on accuracy

39%  How many low ESS regions found?  62%
ACCURACY

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
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!)
## Subjective Responses

<table>
<thead>
<tr>
<th></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>x</td>
</tr>
<tr>
<td>I was able to perform the task efficiently.</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>I am confident I found all the low ESS regions.</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>I am confident all the places I marked are really low ESS.</td>
<td></td>
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</tbody>
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FINDINGS SUMMARY

• 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