PERCEPTION, COGNITION, AND EFFECTIVENESS OF VISUALIZATIONS WITH APPLICATIONS IN SCIENCE AND ENGINEERING

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DATA
initial disease
low ESS
ESS = endothelial shear stress
(i.e., frictional force from blood flow)
plaque
very low ESS
This can rupture and give you a heart attack!

Low ESS = BAD
cannot directly measure ESS in living patients!

NON-INVASIVE DIAGNOSIS

Obtain patient CT data
Segment arteries
Patient specific blood flow simulation
Clinical decision
Visualize and analyze data

Initial disease
low ESS

Visualizations with Applications in Science and Engineering

Chris Beaumont, Tom Robitaille, Michelle Borkin, & Alyssa Goodman (glueviz.org)

INPROV

Michelle Borkin, Krzysztof Gajos, Amanda Peters, Dimitris Mitsouras, Simone Melchionna, Frank Rybicki, Charles Feldman, & Hanspeter Pfister,
“Evaluation of Artery Visualizations for Heart Disease Diagnosis” (IEEE TVCG / InfoVis 2011)
### Formatative Qualitative Study

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

### Task Taxonomy

<table>
<thead>
<tr>
<th>Task</th>
<th>Abstraction</th>
<th>Clinical</th>
<th>Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Identify regions of low ESS&quot;</td>
<td>find extrema</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>&quot;Identify stenosis or blockage&quot;</td>
<td>find extrema</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>&quot;View all ESS data for patterns&quot;</td>
<td>cluster</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>&quot;Study blood flow velocity patterns&quot;</td>
<td>find anomalies</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>&quot;Identify regions of blood recirculation&quot;</td>
<td>find anomalies</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>&quot;Investigate other physical variables of blood flow&quot;</td>
<td>find anomalies</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### LAYOUT AND PROJECTIONS

3D vs. 2D

Clay et al. (2019)
QUANTITATIVE STUDY: GOALS

- 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)

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

e.g., Participant A
e.g., Participant B
RESULTS

Strong effect of **dimensionality** on accuracy

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

ACCURACY

39% How many low ESS regions found?
91%

How many low ESS regions found?

ACCURACY

Participants more **efficient** in **2D**.

EFFICIENCY

Participants more **efficient** in **2D**.

- 5.6 sec/region
- 2.4 sec/region

- 2.6 sec/region

EFFICIENCY

Rainbow color map has greater effect on efficiency in 3D.

EFFICIENCY

- 10.2 sec/region
- 2.6 sec/region

- 5.6 sec/region

- 2.4 sec/region

EFFICIENCY

Accuracy decreases with increased data complexity in 3D

COMPLEXITY

(Not true in 2D!)

- 10.2 sec/region
- 2.6 sec/region

- 5.6 sec/region

COMPLEXITY

- 2.4 sec/region

- 2.6 sec/region

- 5.6 sec/region

- 2.4 sec/region

FINDINGS SUMMARY

- 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

FINAL REMARKS

- **3D** representation is still essential for surgical planning
- **2D** tree diagram applicable to other applications

• 3D representation is still essential for surgical planning
• 2D tree diagram applicable to other applications

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Research funded through the NDSEG (National Defense Science and Engineering Graduate) Fellowship Program, and the NSF Graduate Research Fellowship Program.