### **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





### EVALUATION OF ARTERY VISUALIZATIONS FOR HEART DISEASE DIAGNOSIS



### EVALUATION OF ARTERY VISUALIZATIONS FOR HEART DISEASE DIAGNOSIS



## NON-INVASIVE DIAGNOSIS





### Generate patient geometries

### Patient specific blood flow simulation





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



initial disease

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

## This can rupture and give



## **PREVIOUS WORK**

### • ESS Vessel Visualization

[e.g., Forsberg, et al. (2000), Kanitsar, et al. (2002), Museth, et al. (2008), Ropinski, et al. (2009)]



## **PREVIOUS WORK**

### • 2D vs. 3D Evaluation

[e.g., Cockburn & McKenzie (2002), Laidlaw, et al. (2005), Tory, et al. (2007), Forsberg et al. (2009)]



[Troy, et al. 2007]

[Laidlaw, et al. 2005]

[Forsberg, et al. 2009]

## PREVIOUS WORK

### Color Map Evaluation

[e.g., Ware (1988), Rheingans (1992), Rogowitz & Kalvin (2001), Kindlmann, et al. (2002)]



## FORMATIVE QUALITATIVE STUDY

- Semi-structured interviews
- I 0 medical doctors and researchers
- Brigham & Women's Hospital (Boston, MA)



## 3D



## 3D





## LAYOUT AND PROJECTIONS





## Color





## Color





## COLOR

3.

0







320 CT Scan Left Coronary Artery Lattice-Boltzman (High & Low Flow Rates) ▼ Open All Data



# QUANTITATIVE STUDY: GOALS 3D vs. 2D rainbow vs. diverging Shear Stress (Pa) Shear Stress (Pa)



- 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

- Dependent measures:
  - In the fraction of low ESS regions identified
  - In number of false positives (i.e., non-low ESS regions) identified as low ESS)
  - time to complete a diagnosis















### Results

### ACCURACY

### Strong effect of **dimensionality** on accuracy



How many low ESS regions found?

-2.25 -1.50 -0.75



### 62%

## ACCURACY

# Strong effect of **dimensionality** on accuracy ...as well as **color**

39%



ESS (Pa)

-2.25 -1.50 -0.75





### 9|%

### EFFICIENCY

### Participants more efficient in 2D.



### EFFICIENCY

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



### COMPLEXITY

### Accuracy decreases with increased data complexity in 3D



### COMPLEXITY

# Accuracy decreases with increased data complexity in 3D (not true in 2D!)



### SUBJECTIVE RESPONSES 2D

- I found it easy to identify low ESS regions.
- I was able to perform the task efficiently.
- I am confident I found all the low ESS regions.
- I am confident all the places I marked are really low ESS.









### 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





### FOR MORE INFORMATION...

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

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

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