Evaluating Mental Workload of Two-Dimensional and Three-Dimensional Visualization for Anatomical Structure Localization

Jung Leng Foo PhD, Marisol Martines-Escobar MS, Bethany Juhnke BS, Keely Cassidy BA, Kenneth Hisley PhD, Thom Lobe MD, Eliot Winer PhD
Iowa State University, Des Moines University, Touro University, Blank Children's Hospital

Purpose

Evaluate mental workload while localizing anatomical structures in both 2D and 3D visualization environments

Metrics

1) NASA-TLX to quantify mental workload
2) Time to perform task was recorded
3) Localization accuracy was evaluated

NASA-TLX

Measured Mental Workload impacts
- Patient safety
- Recovery time
- Overall success of procedure

Measured by six factors
Mental Demand
    Thinking, calculating, searching, etc.
Physical Demand
    Pushing, pulling, controlling, etc.
Temporal Demand
    Time pressure
Frustration level
    Insecure, discouraged, irritated
Effort
    Includes mental and physical
Performance
    Successful in accomplishing goal

Results

Mental Workload Components	Ratings for 2D Group	Ratings for 3D Group
Mental Demand	258.33	172.31
Physical Demand	8.75	21.15
Temporal Demand	61.67	58.86
Performance	209.58	223.85
Effort	154.17	165.38
Frustration	113.75	105.00
Overall Mental Workload	53.75	49.77

Overall Mental Worklod is a weighted average of the above values

Background

- Medical images (CT/MRI) are currently examined in 2D but beginning to shift to 3D
- Suggested that 3D visualization is beneficial to surgical planning

User Group

- 25 Medical students (1 year experience)
- All users have little to no experience with software to view medical images (2D and 3D)

Procedure and Methodology

- Users were divided into two groups (2D or 3D)
- Priliminary questions to determine past experience and NASA-TLX was introduced
- Users trained with 2D or 3D software for 5 minutes to get familiar with software
- Users were tasked to locate three atomical structures with varying complexity; Gallbladder, Celiac Trunk, and Superior Mesenteric Artery (SMA)
- Time to locate all three structures and users locations of structures were recorded
- Users completed NASA-TLX questionnaire to measure mental workload
- Responses were analyzed to understand users experience and software usability
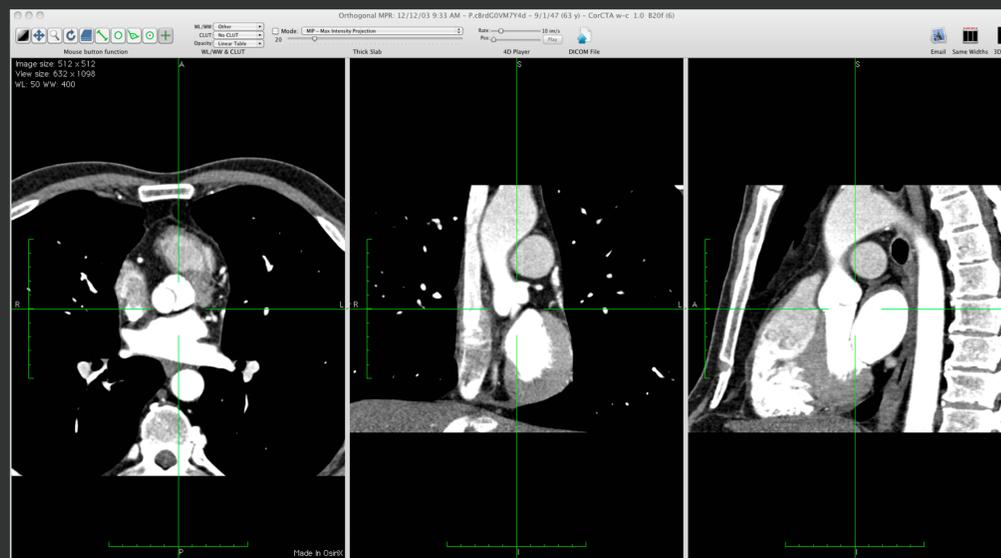
2D User Interface
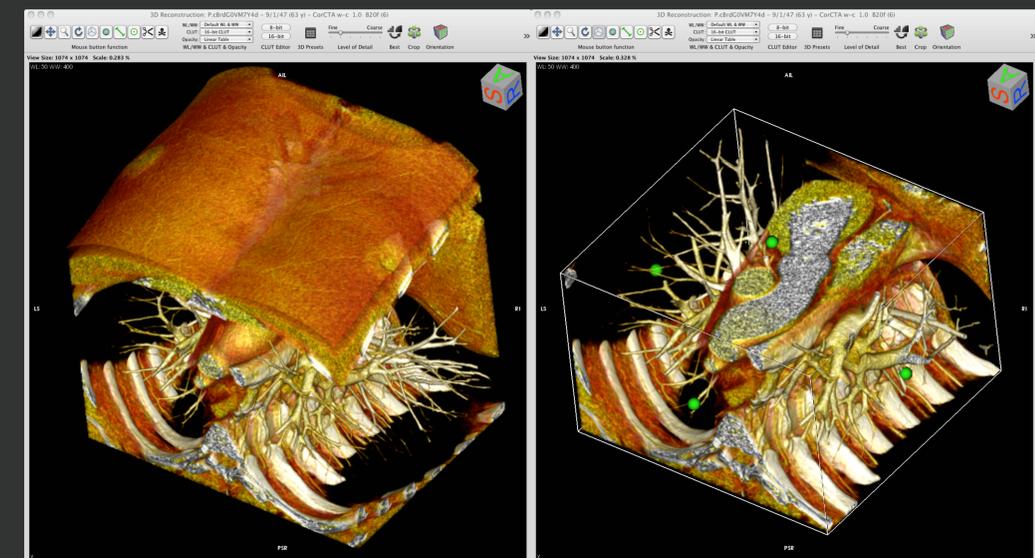
3D User Interface

1) Overall Mental Workload = 53.75
Mental demand is almost 1.5x higher than 3D, users had increased mental demand to form a 3D representation for anatomy localization

2) Time = 6.39 min
2D users quickly scanned slices for familiar landmarks

3) Localization = 2.08/3.00
Other tissue densities would obstruct 2D users' view of the target structure

1) Overall Mental Workload = 49.77
Physical demand is almost 3x higher than 2D caused by more mouse manipulation

2) Time = 10.74 min
3D users explored volume before confirming structure

3) Localization = 2.54/3.00
3D improves localization accuracy
3D users used spatial relationships between anatomical structures

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Virtual Reality Application Center

For questions, contact:
Bethany Juhnke, bjuhnke@iastate.edu