Comparing the Microsoft® Kinect™ to a Traditional Mouse for Adjusting the Viewed Tissue Densities of Three-Dimensional Anatomical Structures

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Purpose

Evaluate user interaction with three-dimensional (3D) medical images when using the Microsoft® Kinect™ and a traditional mouse.

Methodology

- Compared user experience during windowing tasks

Pre-evaluation
- Pre-survey with background information
- Mental Rotation Test (MRT)

Task Performance
- Eight tasks with each device: Kinect™ and traditional mouse
- Task order and order of devices was randomized
- Based on verbal commands, participants adjusted the double handled slider bar to reveal specified anatomy
- Participants were given two-minutes to complete each task

Post-evaluation
- Comparison survey
- Questionnaire for qualitative feedback

Technology

Software
Isis, developed at Iowa State University's Virtual Reality Applications Center

Computer
Dell Precision T5500 with a Xeon W5580 at 3.20GHz CPU
4GB of RAM
nVidia Quadro FX 5800 graphics card

Monitor
24 in. Dell 2408WFPb at 1920x1200 resolution

Kinect
Xbox 360

References

[1] Montgomery, K., Stephanides, M., Schendel, S., and Ross, M. "User Interface Paradigms for Patient-specific Surgical Planning: Lessons Learned over a Decade of Research," Computerized Medical Imaging and Graphics 29, 203–222 (2005).

[2] Gallo, L., Minutolo, A., and De Pietro, G. "A User Interface for VR-ready 3D Medical Imaging by Off-the-shelf Input Devices," Computers in Biology and Medicine 40, 350-358, (2010).

[3] Schneider, U., Pedroni, E., and Lomax, A. "The calibration of CT Hounsfield units for radiotherapy treatment planning," Physics in Medicine and Biology 41, 111-124 (1996)

Background

- Usability is key to integrate 3D imaging into medical environments
- Major barrier is interaction with software [1]
- Commercial-off-the-shelf hardware as interaction devices have gained familiarity and availability in the public market
- Devices enable efficient 3D spatial interaction [2]

Metrics

- One participant's results were removed for timing function error
- 256 tasks were analyzed

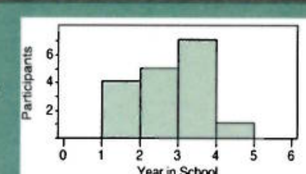
Task completion
- Participants had two minutes to adjust the anatomy via windowing
- 22 (nine for Kinect™ and 13 for mouse) tasks were not completed in the allowed time

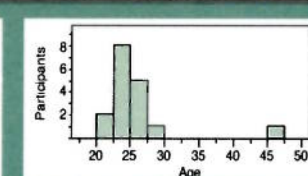
Accuracy
- Specific Hounsfield units (HU) were assigned to the various anatomical structures per task [3]
- 12 (nine for Kinect™ and three for mouse) were determined incorrect

Overall
- 18 tasks were removed from the Kinect™
- 16 tasks were removed from the mouse

User Group

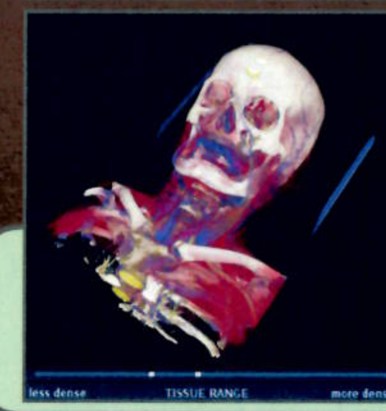
- 17 veterinary medicine students
- All students reported minimal experience with 2D medical images
- Three students had previous experience with 3D medical images





Discussion

- *Interaction device preference: Mouse*
  - Most participants choose the mouse as their preferred interaction device for reasons of recision
  - **Results suggest improvements to Kinect™ interaction design need to be addressed before the device can effectively be implemented as a primary interaction device for 3D medical imaging**
- *Limited use of extreme range of HU with Kinect™*
  - Window center ranges: Kinect™ was 598.5 HU to 2256.5 HU and the mouse was 206 HU to 2508 HU
  - Extreme ranges were much more accessible with the mouse compared to the Kinect™
  - Direct mapping of interaction limited participants access to extreme regions
    - **Research needs to be conducted to improve the mapping between the participants hand locations and the interaction with the software, specifically to improve user access to extreme ranges and small window widths**
- *Novelty factor*
  - Participants were unfamiliar with how to effectively correct when an undesired response occurred
  - A trial and error approach appeared as participants operated the Kinect™ compared to the mouse
- *Task completion time affected by novelty factor*
  - The Kinect™ appeared to have more fumbling that resulted in increased time per task
  - For the mouse, participants used their time contemplating the correctness of their answer, since muscle fatigue was not a factor with mouse operation
- *Overall, the mouse was the preferred interaction device*
  - **Additional research must be conducted to identify standards for effective implementation of the Kinect™ as an interaction device for 3D medical imaging environments**



Task Analysis

- 222 completed and correct tasks were further analyzed
- ***Individual task analysis***
  - Each task was evaluated based on: completion time, window width, window center
  - Four of the 24 task measures were statistically significant, due to small numbers (>16) of data points per task

*Statistical significance below 80% confidence level with p=0.2 was not reported

Task One: Window to make the teeth as visible as possible

- Participants choose a more centralized window center when using the Kinect™ compared to the mouse
- Median window center: Kinect™ was 1903.5 HU and mouse was 2220 HU

*Window center was statistically significant at a confidence level of 80% and p=0.2

Task Two: Window so the skull is clearly displayed with no muscle visible

- Participants choose a more centralized window center when using the Kinect™ compared to the mouse
- Median window center: Kinect™ was 1612 HU and the mouse was 1754.5 HU

*Window center was statistically significant at a confidence level of 80% and p=0.2

Task Four: Window so the blood vessels from the chin to eye sockets are clearly displayed

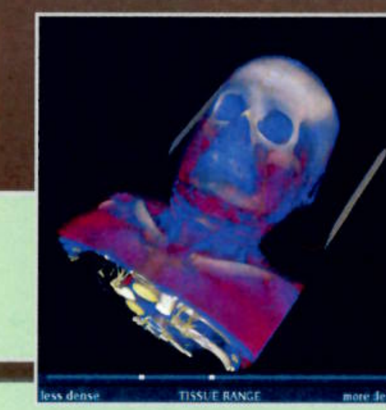
- Participants took less time to complete the task when using the Kinect™ compared to the mouse
- Median completion times: Kinect™ was 25.02 seconds and the mouse was 38.96 seconds

*Time was statistically significant at a confidence level of 85% and p=0.15

Task Six: Window so the skin and soft tissue begin to disappear

- Participants took less time to complete this task when using the Kinect™ compared to the mouse
- Median completion times: Kinect™ was 17.76 seconds and the mouse was 22.70 seconds

*Time was statistically significant at a confidence level of 80% and p=0.2



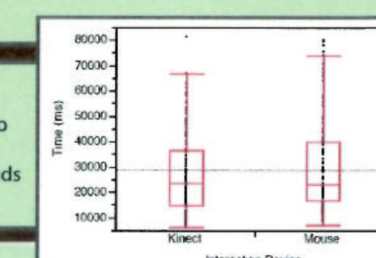
Task Three: Window so the skull and rib cage are isolated
Task Five: Window so the blood vessels and skin are visible
Task Seven: Window so only the skin is showing with no internal anatomies visible
Task Eight: Window so the skin is visible and opaque

*These tasks did not show statistical significance above a confidence level of 80% and p=0.2

Combined tasks analysis

- Overall, the time for participants to complete tasks took less time with the Kinect™ compared to the mouse
- However, median completion times: Kinect™ was 23.82 seconds and the mouse was 23.2 seconds

*Time was statistically significant at a confidence level of 85% and p=0.15



Survey Analysis

- Participants preferred making large adjustments with the Kinect™ and small adjustments with the mouse.

*Adjusting the tissue densities by larger or smaller margins was statistically significant at a 99% confidence level of p=0.01

- Those with higher MRT scores preferred to use the Kinect™ for shifting from higher to lower tissue density ranges compared to those with lower MRT scores

*Correlation was statistically significant at a 90% confidence level of p=0.1

- Overall, participants preferred to use the mouse to obtain their desired range of tissue densities

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