Using Formal Qualitative Methods to Guide Early Development of an Augmented Reality Display System for Surgery

C.H. Lio[1], C.M. Carswell[1,2], Q. Han[1], A. Park[3], S. Strup[4], W.B. Seales[1], D. Clarke[1], G. Lee[3], & J. Hoskins[5]
[1]University of Kentucky Center for Visualization and Virtual Environments, [1, 2]Departments of Psychology, [4]Urology, and [5]Minimally Invasive Surgical Center
[3]University of Maryland, Department of Surgery

Introduction

Conventional laparoscopic surgical visualization systems impair surgeons' depth perception and eye-hand coordination. To better support this challenging surgical approach, there have been technological developments and integrative surgical innovations such as augmented reality (AR).

However, such undertakings often overlook the value of user feedback during the conceptual design stage of development.

Study Goals
To collect feedback from surgical experts to advance our development of the dual-view display.

To explore the feasibility of expert knowledge elicitation as a systematic method in assessing the early development of surgical display innovations.

Knowledge Elicitation

Knowledge elicitation consists of a range of techniques that collect a domain expert's knowledge and problem-solving cognitive processes (Cooke, 1994; Shadbolt and Burton, 1995).

Semi-structured and prototyping selected for this study are examples of such techniques. They offered the flexibility to question the participants in addition to the interview guide questions.

Augmented Display System

The initial development of the dual-view display concept was guided by cognitive ergonomics principles such as:

- Exploitation of redundancy, context, & expectancy
- Reduction of information access effort, and
- Reduction of memory loads

Dual-View Display
The display utilizes a visualization integration technique that provides real time images with minimum lag in response to surgeons' inputs.

It registers the original camera view onto pre-built 3D shape models in one of three ways:

- ***Integrated View --*** the camera view is embedded in its approximate location on a panorama created by "stitching" a sequence of images from the scope (Figure 1).

- ***Separate View -*** the panorama and the camera views are displayed in separate windows, with the approximate location of the camera view as a circular, highlighted area against the windows (Figure 2).

- ***Connected View -*** both views remain in separate windows, but now they are visually tethered by added contours (Figure 3).

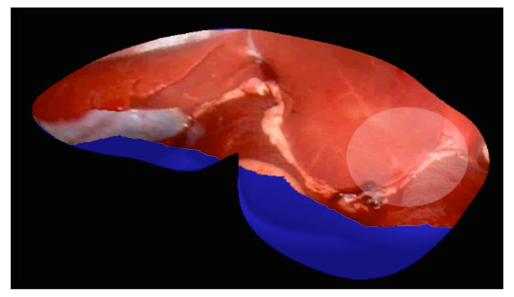
Figure 1. Integrated view.

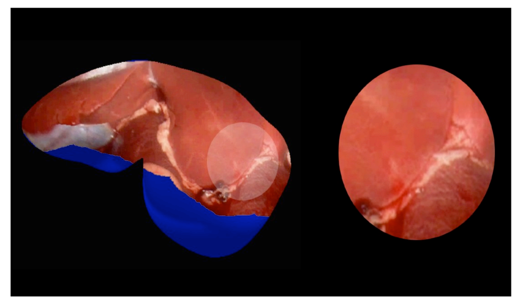
Figure 2. Separate view

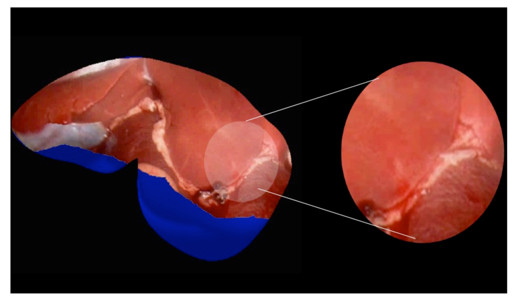
Figure 3. Connected view

Solid/Mesh Frame Dual-View Display

- This display consists of a global view created via nonphotorealistic rendering (Figure 4, left window) & a zoom-in view of a 3D tumor (right window).

- Observation of different angles of the model or tumor is manipulated by a mouse.

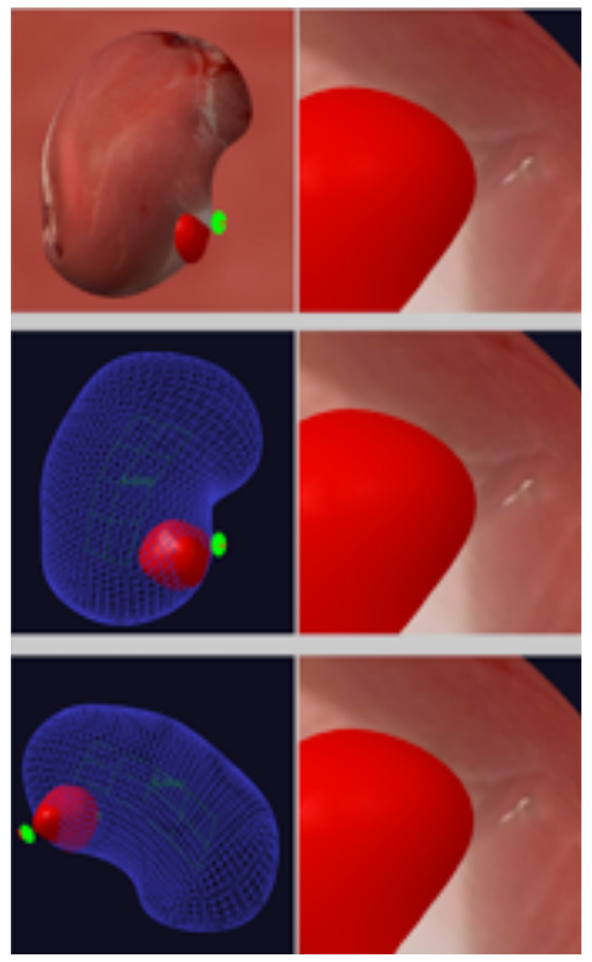
Figure 4. Solid representation of the 3D shaped model of a kidney (top left) and wire-frame representations of the model with a simulated tumor within (Center & bottom left) The windows on the right show views of the 3D shaped model from the tumor.

References

Cooke, N.J. (1994). Varieties of knowledge elicitation techniques. *International Journal of Human-Computer Studies,* 41, 801-849.
Shadbolt, N., & Burton, M. (1995). Knowledge elicitation: A systematic approach. In J.R. Wilson & E.N. Corlett. *Evaluation of Human Work* (2nd ed., pp. 406-440). Philadelphia, PA: Taylor & Francis LTD.

Method

Participants - Two residents, two fellows, and three laparoscopic surgeons (6 M, 1 F; 25-52 years of age) participated without receiving payment. Two male colleagues also participated in portions of the interviews.

Equipment - This included a Dell Latitude laptop computer, projection screen, an audio recorder, and audiocassette tapes.

Semi-structured interview
- Each 30-40 minute session was audio recorded.
- Participants verbalized their thoughts on different aspects of the displays while viewing the prototypes.

Analysis
- Seven themes guided the analysis of the interview transcripts.
- Meaning condensation was used to abridge the 7 central categories of the interview for iterative analyses and interpretations.

Results

Results were summarized into 4 categories:
Relevance to the Informants
The displays seemed to be more relevant to the urologists than general surgery practitioners.

Specific Applications
- All agreed that the mesh frame display would serve as a useful training tool.
- The displays might be appropriate for surgeries such as prostatectomy, partial prostatectomy, adrenal surgery, and tumor ablation.

Significance
- For training purposes, the display might help anatomy and camera orientation, mental ability development, and knowing "what is around and what is nearby."
- The displays might also support pre-, peri- and intra-operative planning.
- Having images in real time is currently not supported by other means.

Improvement Suggestions
The list of suggestions include: 1) camera registration accuracy, 2) a legend and highlight of the camera view in relation to the global views, 3) a you-are-here map, 4) directionality and orientation information, 5) possibly a translucent frame instead of a mesh, and 6) fewer degrees of rotation.

Conclusion

Despite limitations of the relatively brief semi-structured interviews, limited participants, and possible bias in data analyses and interpretations, knowledge elicitation with semi-structured interview/prototyping techniques shows promise for assessing the development of augmented reality display systems for surgical and training applications.