

Superimposing Display Space on Workspace in the Context of Endoscopic Surgery

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ABSTRACT

An experiment was conducted to determine how performance of an endoscopic surgery task is influenced by the location of the image display. Two tasks were performed under two display conditions. The endoscopic camera view of the workspace was displayed either on a monitor in front of the subject or projected directly above the workspace. Timing results revealed significant order by display interactions. Overall, both tasks were faster when the superimposed display was used first. A post-test questionnaire revealed that image quality was perceived to be superior on the monitor. Results are discussed in terms of the subjects' ability to calibrate the display space with the workspace. Implications for surgical operating theatres are discussed.

Keywords

Remote manipulation, interaction devices, visualization, minimally invasive surgery

INTRODUCTION

Endoscopic surgery procedures differ greatly from traditional open surgery. Degraded visual perception of the operating field and the constraints of the manipulation tools pose challenges to surgeons performing procedures endoscopically. An image display acts as the interface between the surgeon and the operating space. Traditionally this interface has been a CRT display located at about the eye level of the surgeon. To improve visualization tools, studies have contrasted 2-D and 3-D viewing [1,4].

In the field of Human Computer Interaction (HCI), research has been conducted on how performance is affected by the location of the display. Graham and MacKenzie [2,3] found that for pointing tasks, superimposing the display space on the workspace is more effective than the standard

desktop configuration. The benefits of superimposing the display on the workspace, by using virtual reality technology, are exhibited in the precision aspects of the pointing task such as with smaller targets and in the 'homing-in' phase of the movement kinematics.

Since surgical tasks require a great deal of precision, performing spatial transformations (camera to monitor to tool in operating space) may result in degraded performance. By superimposing the display space on the workspace, it is expected that surgeons will be better able to calibrate their workspace, and perform more effectively.

METHOD

Participants

Twelve adult university students participated. All participants were right-handed with normal or corrected-to-normal vision.

Apparatus and Set-up

Two displays were used. A Karl-Storz 20 inch monitor was positioned 1.5 m from the participant, 30° to the left, 1.4 m above the floor. The Karl-Storz Video Projection System™ (ViewSite) projected a 25 cm by 20 cm image 44 cm directly above the operating space. The ViewSite was projected directly above the workspace to yield a superimposed display. The image of the operating space was obtained with a Karl-Storz single chip camera and 0° endoscope.

The workspace consisted of an Ethicon grasper and endobox (a completely enclosed container with ports of entry for the endoscope and grasper). The endobox contained the operating space with objects to be manipulated by the participant.

The operating space contained a collection of 5 stainless steel pins organized in a star formation in an acrylic holder. Each pin was 2 mm in diameter and of varying exposed lengths (0.50, 0.75, 1.25, 2.00, 3.00 cm). The pins and grasper were connected to a 5 Volt D/C power source. This provided times associated with components of the tasks.

Procedure

Order of display and tasks was counterbalanced. The two tasks were called touching and grasping. In the touching task, participants were instructed to touch tips of 5 pins in a counterclockwise order. The grasping task was similar except participants were instructed to grasp, pull out and drop each pin. After the experiment, the subjects filled out a questionnaire on image quality, ease of tasks, comfort and preference of display system.

Data Analysis

Data were analyzed in terms of contact times. Total time was decomposed into sequences of contact events; eg: time to pin 1, time on pin 1, time to pin 2 etc. Time to pins 2, 3, 4, and 5 were averaged for a 'time to' measure where time on pins 1, 2, 3, 4 and 5 were averaged for a 'time on' measure. Repeated measures ANOVA was performed on the 2 (display) by 2 (task) by 2 (order of display) design.

RESULTS

For total time, touching the pins took significantly less time than grasping them ($p < 0.0001$). Significant order by display interactions were found for both tasks ($p < 0.01$). The average time spent completing the tasks was less for those who used the superimposed display (ViewSite) first. Also, the time difference between display conditions was greater for those who were presented with the ViewSite first. For all significant order by display interactions in this study, participants were faster on whichever display system they used last which is an expected learning effect.

In the grasping condition, there were significant order by display interactions for both the time to ($p < .001$) and time on ($p < .01$) measures. For both measures, the average time was less for those who used the ViewSite first. When travelling to the pins, the difference between display conditions was greater for those who were presented with the ViewSite first. For time on, the difference was greater for those who used the monitor first. In the touching task, the order by display interaction was significant for the time on measure only ($p < .05$). This followed the same pattern as the time on measure for the grasping task.

The questionnaire revealed effects for image quality only. Participants felt the image quality of the ViewSite was inferior. This was visibly apparent since the ViewSite was a camera projection as opposed to a CRT display.

DISCUSSION

These order by display interactions reveal that the performance in each of the display conditions was a function of which display was presented first. In general, the same pattern of performance was shown for the total time, and time to measures. That is, the difference between display conditions was larger for those who were presented with the superimposed display first. For an aiming task,

participants who used the ViewSite first were better able to calibrate their workspace, and transferring that knowledge to a superior display produced even better results. The fastest times were always for participants using the monitor after having used the ViewSite first. This is expected since aiming requires a good sense of the mapping between display space and workspace. For the time on measure, the difference was greater for those who used the monitor first. This is also expected because once contact with the pins had been made, subjects were not as dependent on the visual information from the displayed image.

In the present study, image quality was not standardized across the display conditions. We expect that if we used the same image generation technique across both conditions, the order effects would be reduced and the advantages of the superimposed display would be highlighted. This work is in progress. See also [5].

CONCLUSIONS

Time in hospital operating theatres is very costly and reductions in surgery time are welcome. Any advances in technology that improve the interface between the surgeon's eyes and hands will not only reduce time, but also reduce errors and enable more surgeons to perform demanding surgical tasks.

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