Poster: Comparing Usability of a Single versus Dual Interaction Metaphor in a Multitask Healthcare Simulation

Lauren Cairco Dukes* Jeffrey Bertrand Manan Gupta Rowan Armstrong Tracy Fasolino
Sabarish Babu Larry F. Hodges

Clemson University

Abstract

We present the results of a user study performed within a multitask healthcare simulation, where nurses are required to care for virtual patients within a 3D virtual environment while recording data in a 2D graphical user interface (GUI) based electronic health record system. We evaluated whether a single interaction metaphor of mouse and keyboard for both virtual and GUI sub-systems of our simulation was superior in terms of user preference and performance to a dual interaction metaphor of using touchscreen for the virtual environment while using mouse and keyboard for the GUI. User preference and performance both indicate that the single interaction metaphor was more usable, although each technique was sufficiently usable for accomplishing simulation goals.

Index Terms: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—virtual reality; H.5.2 [Information Interfaces and Presentation]: User Interfaces—Input devices and strategies; interaction styles; user-centered design

1 Introduction and Motivation

This paper focuses on providing usable 3D interaction techniques for nurses. In collaboration with St. Francis Hospital System, we designed a virtual hospital ward to provide learning opportunities by simulating a nurse's patient observation tasks. We have designed interaction techniques for a demographic that is dissimilar to most users of virtual environmnents (VEs): practicing nurses[9, 1]. Because of this contrast in demographics, we must design for usability and not depend on previous experience in VEs. However, we can leverage nurses' existing medical knowledge.

Our simulation requires integrating input devices for two differing tasks: interaction with the patient and his or her environment within a virtual hospital room, and data review and recording within a 2D simulated electronic health record (EHR). Since the EHR is a traditional 2D GUI application, we designed it for mouse and keyboard interaction. We employed user-centered techniques to design 3D interaction capabilities for virtual hospital rooms suitable for a touchscreen. In this paper, we present the results of a user study comparing the single interaction metaphor of mouse and keyboard to the dual interaction metaphor of touchscreen on one monitor plus mouse and keyboard on the other monitor in our simulation.

2 Related Work

Many researchers have successfully implemented virtual reality simulations for healthcare. For example, Chodos et al. [6] implemented a simulation to allow emergency medical technicians to practice procedures associated with assessing and stabilizing an accident victim. Gupta et al. [7] created a simulation to train healthcare workers in correct hand hygiene procedures. None of these systems present usability results specifically related to their 3D interaction techniques. Additionally, each of these systems requires little to no data entry, while a considerable portion of our simulation depends on the nurse being able to accurately input data into the patient's EHR.

*e-mail: {LCairco, jbertra, mgupta, rarmstr, tfasoli, sbabu, LFH}@clemson.edu

Figure 1: A screenshot of the application. The virtual hospital room is shown on the left, and the electornic health record is shown on the right.

3 System Description

We designed the virtual hospital ward for a dual-monitor computer. On the left monitor, the VE simulates the patient's room. The right monitor displays the patient's EHR. More details about the system can be found in [5]. We modeled the patient's EHR after the system at St. Francis Hospital to reduce frustration associated with learning a new records system. Nurses input data using familiar 2D widgets including radio buttons, and numerical input.

Since nurses are familiar with the hospital setting and patient care tasks, we replicated the hospital setting as realistically as possible. Upon starting the application, the system displays the patient in a hospital room with several interactive medical instruments present. For example, the nurse can measure the patient's heart rate and other statistics by reading digital output on the "nurse-on-a-stick", or listen to the patient's chest to hear heart sounds.

We designed the virtual hospital room to be usable for touch screen interaction. We hypothesized that nurses would find the touch-based interaction more similar to their everyday interaction with the instruments and patient, since they physically use their hands to interact with the patients and their hospital room. We adhered to the design guidelines for touch as proposed in [2]. Our design is also compatible with mouse interaction, since selection may be accomplished by clicking instead of touching, and targets large enough for selection using a finger are also large enough for mouse selection. We opted for menu-based interaction with the instruments similar to the floating menu technique used in [3]. Using menu commands, the nurse selects an instrument's functionality and the camera is automatically repositioned and zoomed in so that the instrument is easily readable. We provide a "Back" button so the nurse can return to the original viewpoint.

4 Usability Evaluation

We conducted a user study to evaluate whether the touch-enabled VE promoted usability. We chose a within-subjects design so that

we could gather preference data and compare performance between two interaction techniques. The first interaction technique was using a mouse for both the VE and EHR screens. The alternate technique was to use a touch screen while in the VE and the mouse for the EHR.

After filling out pre-questionnaires, the participant watched a presentation that demonstrated how to use the system. The participant then completed two trials of five tasks each, using a different interaction metaphor for each trial. For each task, the participant used an instrument in the virtual hospital room and then recorded the result in the EHR. Our two trials were always in the same order, but to counter learning effects, we counterbalanced the ordering of the interaction techniques. After each trial, the participant completed the NASA TLX questionnaire to assess perceived workload [8]. After finishing both trials, the participant completed the Systems Usability Scale [4]. Lastly, the experimenter interviewed the participant for qualitative feedback.

Seventy-seven baccalaureate nursing students completed our experiment. Five participants were male, while 72 participants were female. The mean age was 22.60 years (sd=4.32). Participants reported high familiarity with computers and touch screens, and somewhat lower familiarity with virtual reality.

4.1 Results

We analyzed participants' click and timing data as averages within trials. For the average time between clicks, there was no difference in the average time per click due to interaction technique. For the percentage of "missed" clicks, or clicks that the system registered, but did not hit a target within our VE or EHR, there was also a significant effect of the interaction technique. There was also a significant interaction effect between the interaction technique and the participants' condition. We also analyzed the time between clicks where the participant transitioned from the virtual hospital room to the EHR. There was no significant difference in the transition time between clicks due to the interaction technique. There was also no significant difference in EHR recording accuracy due to interaction technique.

For perceived workload as measured by the NASA TLX, there were significant differences between the interaction techniques in both the physical and effort subscales. The touch/mouse interaction technique mean score was significantly higher than the mouse only interaction technique, with a significant interaction effect between the interaction technique and the ordering. Although the results were not significant for any of the remaining subscales, the touch/mouse interaction technique received higher workload scores than mouse only in all but the performance subscale. All subscales received a mean score of below 200 for either condition, indicating that neither techniques require a prohibitively difficult workload.

The mean SUS score was 85.41% (sd=9.73%), indicating that the users found our system to be highly usable regardless of interaction technique. Users were nearly evenly split in their overall preferences for interaction technique–39 participants preferred mouse only, 37 participants preferred the dual interaction metaphor, and one participant was neutral. When choosing a preference for which interaction technique was easiest, most comfortable, and most accurate, participants chose the mouse significantly more often than the touchscreen/mouse configuration. There was no significant effect of the participant's condition on their preference.

We asked participants to name the best and worst things about each of the interaction configurations. Overall, the most reported best characteristics of the mouse were accuracy and not having to switch interaction techniques. The worst attributes of the mouse were reported to be having to move the mouse between screens and losing the cursor. The best traits of the touchscreen/mouse interaction were that it was fun or engaging, and that it was perceived as easy. Participants reported that the worst attributes of the touchscreen/mouse interaction were inaccuracy and having to switch interaction techniques between screens.

4.2 Discussion

Overall, participants were able to successfully use our system to complete their tasks. However, in nearly all qualitative and quantitative measures, the mouse only technique was superior to the touch/mouse technique. We originally hypothesized that nurses would report that the touchscreen interaction in the hospital room was more similar to their everyday patient interaction than using the mouse. Only one participant made a comment supporting our hypothesis, saying that it was "almost like work because I touch my patients then I use the computer to chart [on the EHR]". Based on this comment, future experiments may confirm our hypothesis.

We hypothesize that our results will hold true in other multitasking VEs. Contrary to our original hypothesis, it seems that users preferred using the same interaction technique for both 3D and 2D interaction due to the frustration associated with changing interaction techniques. Our observations suggest that users prefer to interact using the least frustrating technique for both tasks, regardless of whether the interaction technique is the most realistic fit. Although unrealistic, the dropdown menus were usable, and did not seem to greatly affect the user's perception of the system's realism.

While the mouse only interaction technique met the usability goals of speed, accuracy, and comfort, the touchscreen met alternate usability goals of user engagement and fun. Providing options for interaction techniques that pique user interest may be beneficial, since engaging simulation techniques may aid in capturing user attention. However, although many users perceive touchscreen interaction positively, performance in terms of time and accuracy suffered, and users did not enjoy switching between interaction techniques.

ACKNOWLEDGEMENTS

This work was supported in part by the NSF GRFP (fellow ID 2009080400), the NSF REU Site Grant CNS-0850695, St. Francis Hospital, and a grant from the College of Health Education and Human Development at Clemson University.

REFERENCES

[1] National sample survey of registered nurses (nssrn) - health indicators warehouse. `http://healthindicators.gov/Resources/DataSources/NSSRN_107/Profile`. Accessed 11/26/2012.

[2] Windows development center guidelines for touch. `http://msdn.microsoft.com/en-us/library/windows/desktop/cc872774.aspx`. Accessed 1/19/2012.

[3] D. A. Bowman and C. A. Wingrave. Design and evaluation of menu systems for immersive virtual environments. In *Virtual Reality, 2001. Proceedings. IEEE*, pages 149–156. IEEE, 2001.

[4] J. Brooke. Sus-a quick and dirty usability scale. *Usability evaluation in industry*, 189:194, 1996.

[5] L. Cairco, J. Bertrand, M. Gupta, R. Armstrong, S. Babu, L. Hodges, and T. Fasolino. Towards simulation training for nursing surveillance. *Carolinas Women in Computing*, 2012.

[6] D. Chodos, E. Stroulia, P. Boechler, S. King, P. Kuras, M. Carbonaro, and E. de Jong. Healthcare education with virtual-world simulations. In *Proceedings of the 2010 ICSE Workshop on Software Engineering in Health Care*, pages 89–99. ACM, 2010.

[7] M. Gupta, J. Bertrand, S. Babu, P. Polgreen, and A. Segre. An evolving multi-agent scenario generation framework for simulations in preventative medicine education. In *2nd ACM SIGHIT Internal Health Informatics Symposium*, January 29-31 2012.

[8] S. G. Hart and L. E. Staveland. Development of nasa-tlx (task load index): Results of empirical and theoretical research. *Human mental workload*, 1:139–183, 1988.

[9] N. Yee. The demographics, motivations, and derived experiences of users of massively multi-user online graphical environments. *Presence: Teleoperators and virtual environments*, 15(3):309–329, 2006.