Comparison of Simulated Ovary Training Over Different Skill Levels

Andrew Crossan, Stephen Brewster

Glasgow Interactive Systems Group
Department of Computing Science
University of Glasgow, Glasgow, G12 8QQ, UK

Tel: (0141) 330 3541
Email: {ac, stephen}@dcs.gla.ac.uk
Web: http://www.dcs.gla.ac.uk/~stephen

Stuart Reid, Dominic Mellor

Faculty of Veterinary Medicine
University of Glasgow, Glasgow, UK

Tel: (0141) 330 3541
Email: {s.w.j.reid, d.mellor}@vet.gla.ac.uk

Abstract

This paper describes an initial attempt to compare performance levels of users of different skill levels on the Glasgow Horse Ovary Palpation Simulator (HOPS). Experimental participants were asked to identify the position and size of follicles on the surface of virtual horse ovaries. The two experimental groups were made up of expert and novice users. Experienced large animal veterinarians were chosen as expert users, and second year veterinary students were chosen as novice users. The initial results of the study suggest that novice users perform better than expected. Some possible reasons for this are discussed.

Keywords

Haptic, force feedback, medical simulation, virtual reality training.

Introduction

Virtual Reality is increasingly being recognised as a potential tool for providing training in medical procedures. It offers a safe controllable, environment for medical personnel to practice and learn new skills with no risk to patients. However, validation of a medical simulation proves difficult. Ethical considerations often prevent doctors who are trained using untried methods from working on patients. Particularly as a simulator may provide no training, or may even have a negative effect on training. Studies have shown that simulators can be used to improve performance on the simulator, as well as psychomotor skills [8], but there is little evidence to suggest that these improvements carry over to actual surgical procedures. O'Toole *et al.* [10] describe an experiment where experienced surgeons perform significantly better than medical students on a surgical simulator. They conclude that their simulator may be useful in quantifying surgical skill.

Although Virtual Reality simulation is a relatively young area in medical training, simulation is already a well established method of providing training in medicine. Students gain experience in certain techniques through use of plastic or rubber models, but these often lack realism and provide no useful feedback to the trainee. Surgical and diagnostic skills can also be improved in the anatomy labs that are incorporated into the medicine and veterinary medicine courses. Again, there are problems since cadavers are a scarce resource, and are not generally reusable. Living tissue can also have noticeably different haptic properties than cadaver tissue. VR medical simulators have the potential to present anatomical and physiological information to the user simultaneously on reusable models. Simulations currently developed can be divided into those that provide training for minimally invasive surgery (MIS), surgery, or palpation procedures. MIS simulators are by far the most common. In a MIS procedure, surgeons view their interaction with the patient through a monitor, and hence, it lends itself to a virtual simulation. The Preop endoscopic simulator [4] developed by HT Medical Systems is one example of a system combining a force feedback MIS training system with anatomical and physiological models. Other systems exist to simulate other MIS procedures such as arthroscopy or laparoscopy. SKATS [1] and VE-KATS [11] present knee arthroscopy training systems.

Surgery simulations cover a wide range of techniques using different surgical instruments. Cathsim [2] is an example of a commercially available training system for venipuncture. Berkley *et al.* [3] present a simulation for training in wound suturing.

The development of a palpation simulation presents different problems than development of a surgery simulation. During surgery, a medical practitioner interacts with the patient through surgical instruments, so the haptic feedback from the tissue to the surgeon is mediated by the instruments. In palpation procedures, the doctor is in direct contact with the patient. Burdea et al. [5] describe one of the few examples in the literature of simulation of a procedure involving palpation. Their comparison of rubber and virtual prostate models indicated that although rubber models provided better recognition, the virtual tumour models were also recognisable by experienced doctors. Dinsmore *et al.* [7] also describe the development of a palpation simulator for training in detection of sub surface tumours.

This report describes an ongoing experiment that uses the Horse Ovary Palpation Simulator (HOPS) developed at Glasgow University to compare the performance of experienced and novice veterinarians in horse ovary palpation.

Ovary Palpation

Traditionally, students are taught horse ovary palpation through books, lectures, and practical experience. However, the high cost of keeping horses often leads to a large ratio of students to horses. As ovary palpation is a stressful procedure for the horse, ethical considerations limit a student's opportunity to gain experience. A horse ovary examination can be difficult for a veterinary student to perform, but can also be fatal to the horse if performed incorrectly. Students are only exposed to conditions that occur during their training, and may not get experience in diagnosing rare or unusual cases. Virtual Reality offers a method of providing training for any condition that has been modelled. Access can also increased for seasonal examinations, like pregnancy diagnosis, as the simulator can be used all year round.

During an ovary examination, the veterinarian inserts a gloved hand into the pelvic area of the horse through the rectum. The veterinarian must search through the pelvic region of the horse for the uterus. The ovaries are attached to the uterus, and each can be found by following either the left or right uterine horn. This is difficult in itself, since the veterinarian must perform this search through touch alone while wearing gloves. It usually requires several attempts before an inexperienced student can locate an ovary. Once located, the veterinarian will cup the ovary with one or more fingers, and palpate it using his/her thumb. In particular (s)he will look for any abnormalities in the shape or surface properties of the ovary, and through training and experience, will be able diagnose different conditions through touch alone.

For the purposes of HOPS, follicles of different sizes could be placed on the ovary models. A follicle is a spherical fluid filled sac that grows on the surface of an ovary with some of the sac existing under the surface of the ovary. It will typically grow from very small – a few millimetres – to a few centimetres in diameter. As the follicle grows, it will also tend to move towards the centre of the ovary. Depending on the size, position and feel of the follicle a veterinarian can diagnose the stage of ovulation of the horse. There may be many follicles on an ovary, but only one active follicle exists at the one time.

The Glasgow Horse Ovary Palpation Simulator (HOPS)

HOPS consists of a left and right ovary model fixed in space. The two skills that are important in ovary palpation are locating and identifying the ovaries, and palpating the ovaries. HOPS attempts to provide training to veterinary students in the palpation stage of a horse ovary examination. The left and right virtual horse ovaries can be seen in figure 1.

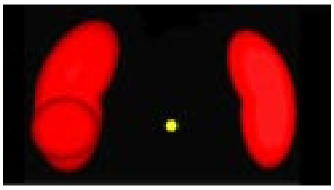

Figure 1: The Horse Ovary Palpation Simulator. This environment consists of a left and right ovary. On the bottom half of the left ovary, a spherical follicle can be seen. The user's cursor is shown as the yellow sphere in the centre.

A user can interact with HOPS through the PHANToM force feedback device from Sensable Technologies [9]. The haptic properties of the models have been developed in conjunction with experienced horse veterinarians at Glasgow University Veterinary School. A selection of veterinarians were asked to set softness, friction and damping properties for the models. Using this method a "good approximation" of actual ovary properties was achieved.

A previous study using HOPS has shown that over one training session, participants trained using the HOPS simulator perform similarly on specimen ovaries than participants trained using traditional methods [6]. Participants in this experiment were veterinary students with little or no horse rectalling experience. In this case, performance was based on the correct location and sizing of a single follicle on the virtual ovaries. This study also showed that there was a low percentage of correct identification in both cases (~11% correct), which suggests current methods can be improved upon. This experiment will build on the previous work with the HOPS simulator.

Overview of Experiment

Training

The experiment was split into training and task stages. As none of the participants had any previous experience in using the PHANToM, they were initially presented with the standard 'Blocks' demo developed by Sensable Technologies to familiarise them with the device. The training stage focussed on training users to locate and distinguish objects by size and softness using touch alone. The training environment consisted of two spheres (shown in Figure 2).

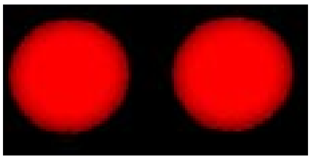

Figure 2: The training environment consisting of 2 spheres.

In the initial training stage, the spheres had identical surface properties but varied in size. Participants had to locate these spheres in the environment, and answer whether the left or right sphere was larger or whether they were the same size. Once a participant answered, (s)he was presented with the next case. Participants had to provide five correct answers before moving on to the next training stage.

The participants were next presented with a similar training environment. In this stage, the spheres remained the same diameter, but the softness was varied. Participants were asked to judge which sphere was softer. This training stage was completed once the participant provided five correct answers.

Next participants were introduced to the HOPS environment. They were shown the models, then allowed to explore them through touch alone for five minutes. A small follicle was present on the front of the bottom left ovary. The training stage of the experiment was then complete.

All users were able to complete the training stage. The time taken in completing the training varied between 18 and 25 minutes.

The Task

The experimental task involved identifying follicles on the surface of the virtual ovaries through touch alone. Participants were presented with the same eight cases but in a random order. In each case, zero, one or more follicles were present on either ovary up to a maximum of five follicles in total. Each participant was given up to five minutes to explore the environment while identifying all follicles. Identification of a follicle involved identifying its position - either left or right ovary, front or back of the ovary, and top or bottom of the ovary - and its size. Participants were told that a follicle could be 2cm, 3cm or 3.5cm in diameter. Timing information for each case was calculated for analysis. Workload measurements were collected from all participants with a NASA TLX workload evaluation form.

There were two subject groups involved in the experiment.

- Group A consisted of second year veterinary students from Glasgow University Veterinary School. At this stage in the course, students have some knowledge of horse ovary palpation through lectures, but have no practical ovary palpation experience.
- Group B consisted of experienced large animal veterinarians. Each participant has years of experience and practice in large animal ovary palpation.

In this initial study, group A contained 10 participants and group B contained 3 participants.

Experimental Apparatus

During the experiment, users interacted with the virtual environments using a PHANToM 1.0 with the standard thimble attachment. The equipment was set up as shown in figure 3 such that a participant received no visual feedback. Participants also wore headphones to obscure noises produced by the PHANToM motors.

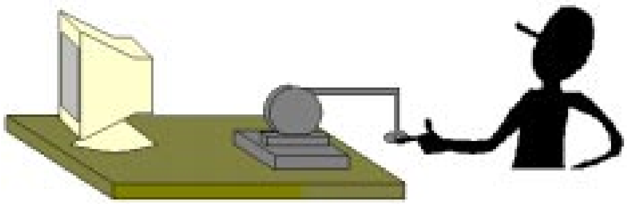

Figure 3: Experimental setup during haptic training. The screen is pointed away from the user so he/she receives no graphical feedback to feel the ovaries.

Hypotheses

1. The measured performance on the simulator of experts group would be significantly better than the performance of the novice group. This performance is measured in accuracy of identifying follicles.
2. The expert group will perform examinations significantly faster than the novice group.

3. The measured workload of the expert group A would be significantly lower than the workload of the novice group. The expert group will show a significantly higher confidence rating.

Results

Performance on the Simulator

Initial results suggest that hypothesis 1 will not be supported. Of the 22 follicles present in the experiment, both groups reported identifying similar numbers of follicles. However differences are noticed in the percentage of follicles correctly placed. Group A placed 70.9% of follicles correctly, where as group B placed 40.9% correctly. The expert group reported problems in placing a follicle on the ovary once found. In a real examination, the veterinarian will hold the follicle while palpating, and will therefore have an idea of the position of any follicle found with respect to the ovary in their hand. This is not the case in the virtual model since users are restricted to one point of contact with the environment.

	Number found per trial	% Correctly Positioned	% Correctly positioned & sized
Group A	18.8	70.9%	36.4%
Group B	17	40.9%	13.6%

Table 1: Results from both groups of performance in identifying follicles on the ovary surface.

Differences were also observed in the techniques used by group A and group B in the trials. Participants from group A tended to maintain contact with the ovary being search, and maintain a steady force to trace the shape of the ovary. Participants from group B tended to move across the ovary surface, repeatedly prodding it and therefore varying force.

Comparison of Timing Data

Figure 4 shows the comparison of timing data between the two groups. There are suggestions from Cases 6, 7, and 8 that the experienced veterinarians may complete their examination more quickly, however, a larger expert group is required before any significant results can be detected.

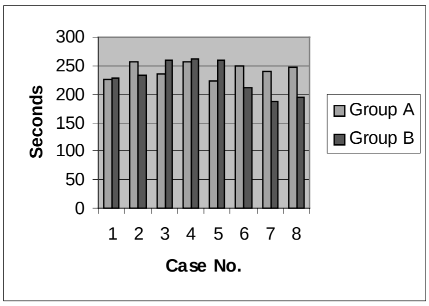

Figure 4: Comparison of the average time to complete each examination

Workload Analysis

Figure 5 shows the comparison of workload between the two subject groups.

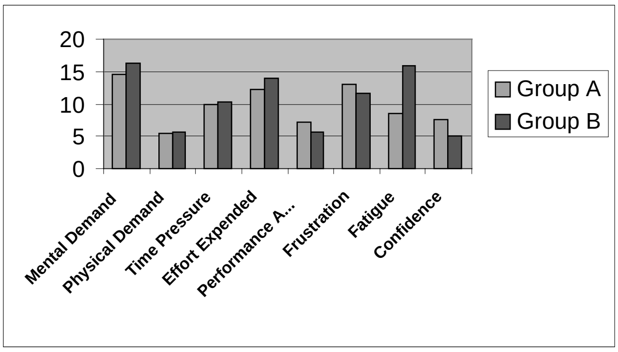

Figure 5: Comparison between the expert and novice groups of subjective workload for the task

Although the expert group is small, it is important to note that the 'Performance Achieved' and the 'Confidence' ratings are low. This is possibly down to the fact that locating follicles on an ovary is performed differently in the simulator and in the real examination. Both groups found the task very mentally demanding.

Future Work

The next stage of the experiment will be to continue with a larger number of expert users. The expert user group just now is too small to be able to draw any conclusions about the significance of results.

During the experiment cursor path and user force information were collected. Further analysis will be performed on this data. Initial aims will be to analyse the path information to detect any differences in techniques between the user groups, and look for similarities within the expert group. Information, such as force used to palpate an ovary will be examined.

We will also investigate techniques for addressing the problems raised by the expert group in positioning follicles on an ovary. Initial tests will involve incorporating two PHANToMs into the workspace. One PHANToM can therefore be used to palpate, the while the other can control the movements of the ovary. This would provide a means of reference to position the follicle on the ovary.

References

1. Arthur, J.G., McCarthy, A.D., Wynn, H.P., Harley, P.J. and Barber, C. Weak at the knees? Arthroscopy Surgery Simulation User Requirements, Capturing the psychological impact of VR Innovation Through risk

based design. In *Proceedings of Interact 99* (Edinburgh UK) IOS Press, 1999, pp. 360-366.

2. Barker, V.L. Cathsim. In *Proceedings of Medicine Meets Virtual Reality* (San Francisco, USA) IOS Press, 1999, pp. 36-37.
3. Berkley, J., Weghorst, S., Gladstone, H., Raugi, G., Berg, D. and Ganter, M. Fast Finite Element Modeling for Surgical Simulation. In *Proceedings of Medicine Meets Virtual Reality* (San Francisco, USA) IOS Press, 1999, pp. 55-61.
4. Bro-Nielsen, M., Tasto, J.L., Cunningham, R. and Merril, G.L. Preop Endoscopic Simulator: A PC-Based Imersive Training System for Bronchoscopy. In *Proceedings of Medicine Meets Virtual Reality* (San Francisco, USA) IOS Press, 1999, pp. 76-82.
5. Burdea, G., Patounakis, G., Popescu, V. and E., W.R. Virtual Reality-Based Training for the Diagnosis of Prostate Cancer. *IEEE Transactions on Biomedical Engineering* 46, 10 (1999), 1253-1260.
6. Crossan, A., Brewster, S.A. and Glendye, A. A Horse Ovary Palpation Simulator for Veterinary Training. In *Proceedings of PURS 2000* (Zurich) Hartung-Gorre, 2000, pp. 79-86.
7. Dinsmore, M., Langrana, N., Burdea, G. and Ladeji, J. Virtual Reality Training Simulation of Palpation of Subsurface Tumors. In *Proceedings of Virtual Reality Annual International Symposium* (Albuquerque, USA) IEEE Computer Society Press, 1997, pp. 54-60.
8. Gorman, P.J., Lieser, J.D., Morray, W.B., Haluck, R.S. and Krummel, T.M. Assessment and Validation of a Force Feedback Virtual Reality Based Surgical Simulator. In *Proceedings of Phantom User Group 98* (Dedham, Massachusetts), 1998, pp. 27-29.
9. Massie, T.H. and Salisbury, K. The Phantom Haptic Interface: A Device for Probing Virtual Objects. In *Proceedings of the ASME Winter Annual Meeting, Symposium on Haptic Interface for Virtual Environments and Teleoperator Systems* (Chicago, IL), 1994.
10. O'Toole, R., Playter, R., Blank, W., Cornelius, N., Roberts, W. and Raibert, M. A Novel Virtual Reality Surgical Trainer with Force Feedback Surgeon Vs Medical Student performance. In *proceedings of Phantom User Group 97*, 1997.
11. Sherman, K.P., Ward, J.W., Wills, D.P.M. and Mohsen, A.M.M.A. A Portable Virtual Environment Knee Arthroscopy Training System with Objective Scoring. In *Proceedings of Medicine Meets Virtual Reality* (San Francisco, USA) IOS Press, 1999, pp. 335-336.