A Horse Ovary Palpation Simulator for Veterinary Training

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Abstract. This paper presents an initial attempt to validate the use of a haptic horse ovary simulator to train students in horse ovary palpation. A horse rectalling procedure is not only difficult for the student, but can be fatal to the horse if performed incorrectly. Maintenance costs limit the number of animals available, and obvious welfare issues exist in performing several examinations on the same set of animals. It was hoped that the simulator would provide a safe, flexible and cheap environment for the student to learn, and would provide skill transfer in ovary palpation techniques. The simulation uses the PHANToM and GHOST toolkit from SensAble Technologies and was developed iteratively in conjunction with veterinarians from Glasgow University Veterinary School. Our experiment to validate the simulator involved three groups of first year veterinary students: Group 1 had no rectalling experience but trained on the simulator; Group 2 had limited rectalling experience and received no simulator training; and Group 3 had no rectalling experience and received no simulator training. Each group was then asked to diagnose properties on a set of specimen ovaries using haptic perception only. The results showed that the students trained using simulator methods performed no worse than the students trained using traditional methods. This invited further work to improve our models. This paper therefore describes further enhancements being carried out to create a learning environment by providing students with added audio and haptic cues.

Background

Although simulators are becoming more common for training in human medicine, Glasgow University's Equine Ovary Palpation project is the only haptic training system aimed at veterinary medicine. The majority of the simulators described in the literature concentrate on surgery simulation, and in particular Minimally Invasive Surgery (MIS) [1] [9]. Commercial examples of haptic MIS training devices are also available [3].

The surgical simulations available cover a wide range of different procedures and instruments. Cathsim [2], a suturing simulation, illustrates a simulation designed for training in venipuncture. Other systems may have different requirements, for example cutting and bleeding models.

The development of a palpation simulation presents different problems from those found in a surgical simulation. During surgery, a surgeon interacts with the patient through instruments; the instruments mediate the haptic feedback. Palpation, however, involves the doctor interacting directly with skin or tissue. The development of palpation simulators is less common, despite the fact that palpation is an important technique for the diagnosis of many conditions. Two recent examples come from the Human Machine Interface Laboratory at the CAIP Center at Rutgers University. They have developed a simulation using the Rutgers Master II for training in palpation for the detection of sub-surface tumours using experimentally based force-deflection curves [5]. They also present a prostate simulator developed using the PHANToM from SensAble Technologies [4], which can model several different prostate conditions.

The Horse Ovary Palpation Simulator (**HOPS**) was developed in close collaboration with Glasgow University Veterinary School. In particular, the Veterinary School provided a technique where a haptic simulation could be beneficial. The procedure chosen was an equine ovary examination for diagnosing the state of ovulation of a horse. As this is an internal procedure, diagnosis is based solely on the haptic properties of the ovary. Students have limited opportunities to practice equine ovary examinations for several reasons. Firstly, the students cannot perform the examination during the winter months when the animal is not ovulating. Also, the high expense of keeping a horse has led to a large ratio of students to animals at Glasgow Vet School. There are the obvious welfare issues since an ovary examination can be particularly stressful for the horse, and can even be fatal if performed incorrectly. It is also an extremely important examination to perform correctly once qualified as a misdiagnosis can lead to the loss of a foetus, which can be expensive for the owner. Another advantage of the simulation is in flexibility in presenting rare cases that students may read about during their training but may not experience until the first time they have to diagnose it when in practice.

An Ovary Examination

During an ovary examination, the veterinarian inserts a gloved hand into the pelvic area of the horse through the rectum. The vet 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.

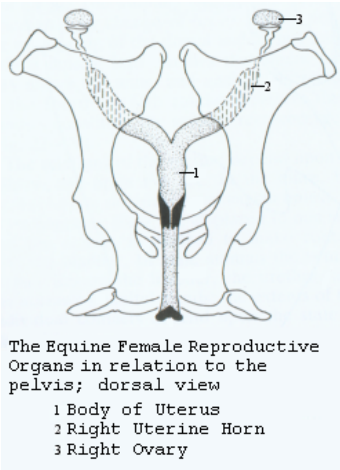

Fig. 1. Dorsal view of the equine reproductive system.

This is difficult in itself, since the vet must perform this search through touch alone. 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 millimeters – to a few centimeters 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 vet can diagnose the stage of ovulation of the horse.

The Simulator

The environment consists of two virtual equine ovaries fixed in space. The ovary models were developed using SensAble Technolgies GHOST Toolkit, and were developed iteratively in close collaboration with Glasgow Vet School. They were built using only combinations of simple geometric shapes, but were judged to be effective by the veterinarians involved. Users interacted with the ovaries using a PHANToM 1.0 with the thimble attachment. One interaction point with the environment allowed users to trace the ovaries, but meant that the ovaries must remain fixed in space. Users were restricted to a small workspace to allow them to find the ovaries without graphical feedback.

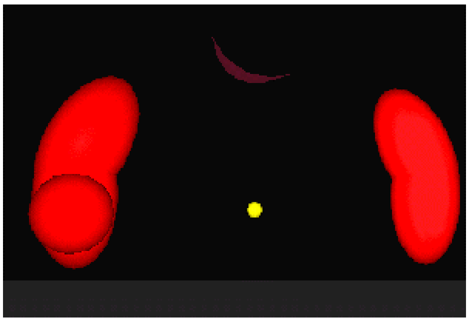

Fig. 2. The Environment consists of a left and right ovary. A spherical follicle is visible on the front of the left ovary.

The surface properties were developed with input from experienced veterinarians. A follicle could be distinguished from the ovaries as the follicle was softer and protruded from the ovary surface.

The Experiment

An experiment was carried out as an initial validation of the simulator. This experiment involved three groups of veterinary students from Glasgow University Veterinary School. Group 1 had no previous experience in rectalling a horse, but received training on the ovary simulator. Group 2 had limited experience of rectalling a live horse (between one and ten examinations), but received no virtual training. Group 3 had no previous rectalling experience, and received no training on the simulator. The experiment therefore involved two stages – training and a specimen ovary examination.

Only Group 1 received virtual training from the ovary simulator. None of the subjects had previous experience with the PHANToM, so they were initially presented with three 3D demonstrations to familiarise them with the device. These demonstrations illustrated how to navigate in the workspace, and allowed them to interact with objects with different surface properties. They were then presented with a haptic only representation of the ovary simulator with no follicle, and allowed to explore it. Finally, they were then presented with 8 ovary models - with either 0 or 1 follicles - and were allowed five minutes to explore each. After each examination, the students answered questions about the size and position of any follicles they found, and hence, the state of ovulation of the horse.

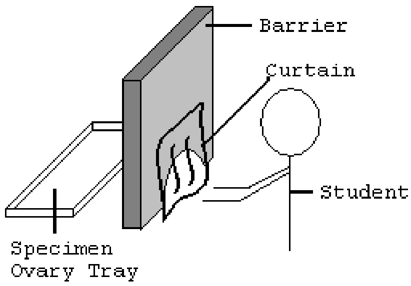

Fig. 3. Experimental Setup

Every group performed the specimen ovary examination. Each group was presented with the same set of eight specimen ovaries in the same order, examinable by touch only, and asked to identify the size, and position of any follicles, and hence the stage of ovulation of the horse. The students were limited to one-hand examinations as in an examination on a live horse. A barrier was placed between the students and the specimen ovaries to ensure that the students could only use touch to identify the ovaries. Students were allowed 5 minutes to explore an ovary, and were presented with questions on the size and position of any follicles. The questions were identical to the questions posed in the virtual training session. The hypothesis was students trained using virtual methods would perform as well as students trained using traditional methods.

Results

For a correct diagnosis, a student must provide the correct size and position of the follicle as well as the correct stage of ovulation of the horse. Table 1 shows the results of the percentage of correct diagnoses for each group of students.

Virtual Training (9 subjects)	**Traditional Horse Training (9 subjects)**	**No Training (8 subjects)**
11%	8%	8%

Table 1. Percentage of correct diagnoses of the stage of ovulation of the horse on specimen ovaries for each group.

Clearly the proportion of correct diagnoses for every group is low, indicating the difficulty of the task set. It does, however, suggest that there is the potential for improvement on traditional ovary palpation training methods. In particular, the virtual training methods had performed just as well as the traditional methods

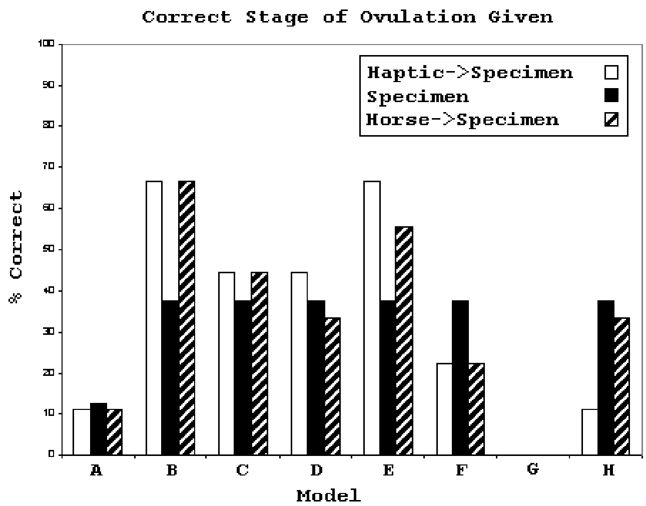

Fig. 4. Correct stage of ovulation given for each group, for each specimen ovary model

Certain specimen ovary models also presented subjects in all groups with difficulties. From Figure 4, it can be seen that models A and G in particular presented problems to the students. These models were the same specimen presented twice such that the left ovary of model A was the right ovary of model G and vice versa. This specimen contained a small follicle that the students struggled to diagnose. Again, for the majority of cases, the group with simulator training performed just as well or better than the group trained with traditional methods.

Future Work and Conclusions

We are currently working to improve the simulator in two areas: increasing fidelity by improving the models, and introducing multimodal feedback cues.

Improving the Models

The shape and feel of the virtual ovaries is particularly important since the users are training to palpate real ovaries. The current models are based on simple geometric shapes, but developing anatomically accurate computer models is difficult. One method, the "Lucky the Virtual Dog" project at EDVEC, [6] uses MRI and CT scans to build up anatomically accurate 3D VRML models. We are also experimenting with different force models to represent the firmness of the virtual objects. Currently the default linear Hookes-Law approach is used, but other non-linear methods have generally been shown to model tissue more accurately. We have incorporated more of the surrounding area into the environment. This includes a pulsing aorta running down the spine, as well as a global viscosity that is experienced during an actual examination. Finally, we are currently conducting an experiment to determine if adding a second PHANToM to the environment - to allow pinching of objects - will increase the user's performance. This will also provide a closer representation of the actual palpation techniques used by veterinarians.

Multimodal Feedback Cues

The aim of this project is to create a learning environment for training users in examination techniques. Higgins *et al.* [8] note that feedback to the student is an important part of any training simulation, and go as far as to say "it is pointless to build a training simulator that doesn't provide useful feedback on performance to the trainee". Examples exist in the literature of performance feedback being presented to the user after the examination [7]. We feel that a simulation can be enhanced by providing additional multimodal feedback to guide users during their exploration of the environment. While these cues would not be available during an actual examination, they could aid during the training phase by providing the user with performance feedback and guidance. An example of an audio cue has already been incorporated into the simulation. The purpose of the cues is to guide the user in the forces to use during palpation. The system monitors the forces applied to the objects in the environment. If the force on a particular object exceeds a predefined safety threshold, an audio warning is played to the user. This warning is of the form of a variable pitch tone, with the pitch being proportional to the force applied above the threshold – the higher the force above the threshold, the higher pitch the warning is.

Haptic cues can provide a method of direct guidance through the environment. This can take the form of playing back pre-recorded movements or as interactive guidance. Pre-recording the movements of an experienced veterinarian and playing them back to a student would allow the student to feel what an examination should feel like. Alternatively, an experienced veterinarian could assess the performance of a student by replaying the student's examination. An initial attempt at providing pre-recorded haptic guidance has been implemented. The recording stage involves sampling and storing position and estimated force information from an examination. Playing back involves echoing the recorded forces back to the PHANToM in the direction of the next sample position to be reached. While this implementation works in free space, it currently suffers from a lack of stability while in contact with objects in the scene.

Interactive haptic guidance could take the form of tutor-student guidance. Two points of interaction would exist in the same scene, with the tutor and student controlling one each. The student could explore the simulation as normal, with the Tutor offering guidance at any time by grabbing the student's cursor, and guiding them through a series of motions.

The low percentage of correct diagnoses for all three conditions shows the difficulty of the experimental task chosen, but also encourages further work to improve the simulator. Training effects for the virtual and traditional training methods will become more noticeable over a period of time. Ideally, providing several training sessions before conducting a similar experiment would provide a better measure of both methods. Trends in the data would also become more noticeable with a larger sample size. One possible benefit of the simulator is in providing training for difficult or unusual cases. From figure 4 students struggled to diagnose model A/G, which contained a small follicle. Simulator training could gradually lead the students into the more difficult to diagnose cases, by presenting similar but easier to diagnose cases.

This paper describes an initial attempt to develop an equine ovary palpation simulator. Additional feedback cues to provide guidance as users explore the environment have also been presented. However, more work is required in developing the ovary models and feedback cues before a useful training system is developed.

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