Haptic Device Medical Training

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1 Introduction

One of the most difficult aspects of medical training is the ability to accurately simulate real world conditions. This paper will address one solution for training students in the use of an endovaginal ultrasound. Due to the nature of the procedure, precautions must be taken to minimize discomfort to the patient. By developing a virtual training system, these and other issues can more than adequately be addressed.

2 Pedagogical Concerns

Endovaginal ultrasound is becoming the standard for obstetric and gynecological imaging and examination due to a number of factors. It is noninvasive and extremely accurate when compared to traditional abdominal ultrasound. By locating the scanner much closer to the pelvic region, it is possible to increase the resolution of scans of the uterus and ovaries. Adjusting the frequency of the ultrasound can allow for increased penetration in scanning depth and comprehensive analysis of uterine endometrial thickness. Several of the areas in which endovaginal ultrasound outperforms traditional abdominal scanning are for detecting uterine abnormalities, ovarian cyst aspiration and follicle surveillance. With these and other advantages, the use of endovaginal scanning is becoming more widespread, hence the need for additional training methods.
Existing simulators rely on technology embedded mannequins to train students in ultrasound techniques. While this provides a relatively lifelike representation of true conditions, there are still a number of limitations. Such devices are quite expensive and can only simulate a library of specific preprogrammed conditions. The portability of these devices is also a limiting factor in the adoption of this technology. At Drexel University, we are developing a new simulator which should address these and other issues.

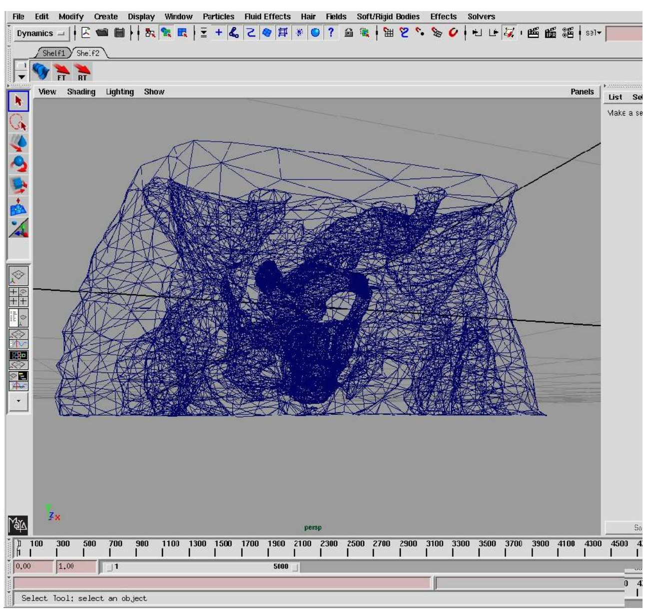

Figure 1:Wireframe view of Lucy Model

Working with Dr. Neal Handly from the College of Medicine and Dr. Michael Atwood from the College of Information Science Technology, we are developing a prototype for a haptic endovaginal ultrasound simulator. Several haptic medical training devices exist, primarily for training in endoscopy, laparoscopy and hysteroscopy. Again, these come with a set of preprogrammed situations in which to study various conditions. What we propose is the creation of a parametric model of the female pelvic region, which can be adaptively reconfigured to provide a huge array of conditions.
The starting point for the digital model is the Lucy model from the Visible Human Project, obtained from the Stanford University Medical Media and Information Technologies Lab. From this initial static position, the anatomy is deformed to represent various states and conditions. These can include bladder state, size of pelvis, term of pregnancy and other common concerns.

3 Process

The haptic device required for the solution needed to rotate about on a pivot on all three axes, as well as allow for lateral sliding. After researching custom solutions, it was decided that the PHANTOM Omni Device made by SensAble technologies would suit the needs of the proposal. In addition to being a low cost device that would handle the necessary degrees of freedom, the OpenHaptics toolkit which works in conjunction with device allows for the level of customization required. Lastly, as the toolkit is modeled after OpenGL, it is familiar to the staff involved on the project. The machine shop at Drexel was used to create a custom housing for the device, enabling it to feel like a true endovaginal ultrasound.

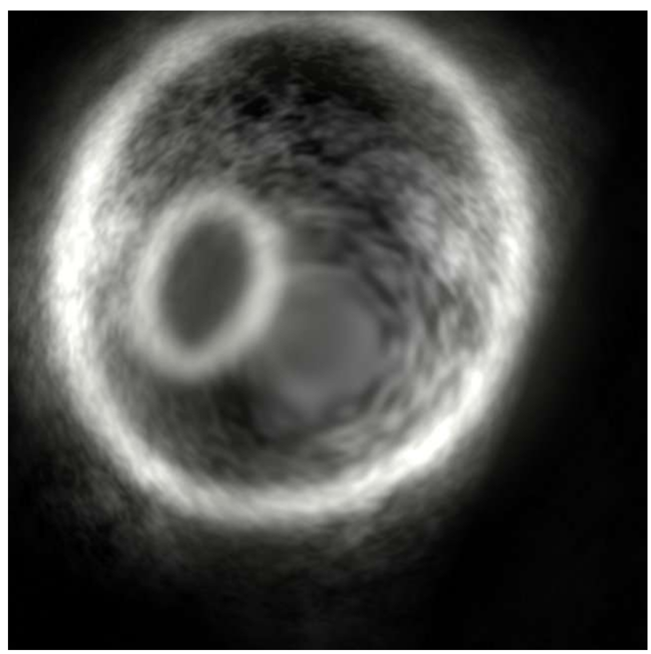

Figure 2:Simulated Ultrasound Image

Once the files were acquired from the Visible Human Project, it was discovered that the .mesh files were not easily translated into any of the animation packages used. To overcome this, a custom plug-in for Alias Maya was written by Drexel student Serge Aluker. This allowed all point cloud data to be read natively into Maya without the need for additional translation. The triangulated point cloud mesh was then subdivided to allow for a denser mesh that would be more suitable for performing deformations and vertex mapping. Much of the mesh was constructed of zero thickness, so the components were modified to reflect accurate mass.

The refined model was then copied, with each iteration representing a different physiological condition, making sure to keep a consistent vertex count. Blendshapes were created and sliders were used to parametrically deform the model into an array of configurations. Care was taken to ensure the model stayed within an anatomically correct bound and interpenetrations were avoided. The shaded output uses volume shaders to approximate the look of a traditional ultrasound.

4 Conclusion

The learning possibilities for a haptic device of this sort are quite extensive, and we plan on taking the implementation further. Currently, collisions are described only by the surface geometry within Maya. However, data exists about the elasticity and pliability of the various organs, and that could also be embedded into the simulation. In that way, more accurate resistance could also be taught and the device could take on more significance. Also, more conditions could be input into the model, allowing for a wider range of conditions and simulations. I would like to thank Dr. Neal Handly, Dr. Michael Atwood and Serge Aluker for their work on this project.