Papers

A Haptic and Visual Biomechanical Model of the Human Uterus and Associated Neoplastic Lesions

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Rapid development of videoendoscopic surgical procedures presents a formidable challenge to the traditional apprenticeship-based training system. Limited access to the operating field, compared to open surgery, is associated with a decrease in the number of visual cues available to surgeons, thereby emphasizing the need to rely on tactile senses, rather than visualization alone. Further, the restricted view complicates instruction of surgical anatomy, pathology and procedures. These challenges are not adequately addressed by the commonly-utilized teaching methods of practicing surgery on animals and even on fresh cadavers. Therefore, the task of developing capabilities for three-dimensional (3-D) human anatomy modeling and for simulating various medical and surgical environments is important, and meeting it is increasingly feasible. Such simulations will become valuable tools for teaching correct execution of surgical manipulations and for enhancing procedural competence and hand-eye coordination skills in surgical residents. Furthermore, accurate physical 3-D representation of human organs and tissues, combined with patient-specific data, will enable surgeons to conduct pre-operative planning and to rehearse complex operations. This is expected to increase utilization of more conservative organ-sparing procedures and to decrease operative times.

We will present a simulation of hysteroscopy—a procedure for examining the uterus for neoplastic lesions—that provides visual and haptic interfaces. The uterus is modeled as a prototype soft-tissue multilayered organ. It is composed of two layers: the myometrium, a thick outer muscular layer, and the endometrium, a thin inner layer the thickness of which fluctuates with the phase of the female hormonal cycle. Each layer is represented as an elastic surface, and deformations are transmitted from the inner to the outer surface by spring/damper elements. Lesions are generated by growing new surface nodes and changing elastic properties of neighboring structures. This simplified 3-D biomechanical model of the uterine wall interacts with a visual display (Silicon Graphics workstation) and a force feedback device (joystick manufactured by Immersion Corp.). Medical validity of the model will be evaluated in simulated tumor recognition and discrimination tests performed by experienced gynecological surgeons and residents at Stanford University School of Medicine.

[We acknowledge loan of the force feedback joystick from Immersion Corp., San Jose, California.]

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