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DIGITAL SURGERY USING A MESHFREE METHOD

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ABSTRACT

Minimally invasive surgical procedures (MIS) are being widely used due to their significant advantages over traditional open surgeries. A major advantage of MIS procedures is that patients recover quickly, dramatically shortening the duration of stay in the hospital. However, the surgeons have to face several difficulties never experienced in open surgeries such as poor depth perception, limited field of view, improper hand-eye coordination and limited force feedback from instruments. Therefore, MIS surgeons need long learning times and repetitive practice to reach a necessary skill level. But their opportunities to practice procedures are limited.

This calls for a training system for surgical residents or medical students. Similar to flight simulators, surgical simulators promise a safer and cheaper way of training. The surgeons can be trained in computer-generated environments where they would interact with 3-dimensional realistic organ models both visually and using their sense of touch (conveyed to them through one or more haptic interface devices). The simulator updates multimodal information seamlessly and responds to users' actions in real time. While the graphical frames are typically updated at around 30- 40Hz, the haptic information needs to be updated at a rate of about 500 Hz – 1KHz for stable haptic interaction.

The extremely high update rates coupled with the complex characteristics of soft biological tissues place stringent requirements on the computational models that can be used. This paper presents new computationally efficient approaches for component tasks so as to optimally manage the limited computational resources during simulation.

The proposed technique is based on a specialized version of a meshfree discretization scheme known as the method of finite speheres [1]. In this technique nodal points are sprinkled locally around the surgical tool tip and the interpolation is performed by functions that are nonzero only on spheres surrounding the nodes. The governing partial differential equations of elasticity are applied at the nodal points only (a technique known as "collocation").

Several techniques of enhancing the speed of this approach will be discussed.

REFERENCES

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