

HAPTIC INTERACTION TO SIMULATE COMPLEX SURGICAL PROCEDURES

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Purpose

The goal of this project is to develop a realistic computer simulation of a surgical environment that can be used to better train medical students before they work on live humans. The focus of our research, in contrast to the sole emphasis of most previous work on physical modeling, is to understand and model the logical flow of specific events that can occur during an operation, so that the student learns the optimal sequence of actions to perform given various scenarios. A primary objective has been to develop scenario authoring tools to allow for the virtualization of the curriculum of specific surgical procedures.

Material and Methods

A prototype of such a discrete event engine has been implemented. A surgeon can design an input script for a procedure by defining a set of states, each with associated actions, and transitions among states, each triggered by detection of a specific event. The program defines a library of action and detection functions, which are used in the script, along with parameters for specifics such as length, force, or location. The framework for the software development is the Simulation & Active Interface platform for graphics and haptics developed at Stanford, including a proxy algorithm, collision detection methods, and stereo 3-D graphic rendering. In addition, we have developed support for multi-finger haptic gripper interaction.

Results

A demo has been created using simple texture-mapped geometric primitives that interact with the discrete event engine, driven by user input from a one-finger desktop Phantom haptic device. In the demo, the surgeon cuts through the skin and muscle layers of a thorax, ties an artery, excises a tumor, and sutures the incision back together. He/she must select the proper tool for each step. If a cut is made in the wrong place or with excessive force, bleeding starts, and the location must be sutured within a given time frame or the patient dies. The amplitude of a simulated heart monitor signal and the associated volume of the beeping help indicate the state of the patient.

Conclusion

Significant progress has been made towards achieving the aims of our proposed research. We are continuing work on improved graphic and haptic models of tissues and organs, enhanced coordination among multiple haptic devices and multiple users, and more realistic and complex surgical procedures.