

Trans-World Haptic Collaboration

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Abstract

This sketch describes a collaborative virtual environment application involving haptic interaction over long Internet distances. We have developed algorithms to accommodate significant latency for certain applications, notably in the medical domain. The results have shown that we can manipulate simulated human body organs, as well as guide each other's 'hands' (and shake hands!) over 22,000 km.

1. Haptics in Collaboration

In a graphics-only system, a user typically reacts to a change only after it has been consciously processed in the brain, creating, effectively, an adaptive low pass filter. With haptics, the effects of latency are significant, due to the direct exchange of energy between the user and the system, via the user's flesh, muscles and tendons. These responses can produce instability when there are dynamic objects in the scene and there is significant latency.

It has previously been thought [Matsumoto, S. 2000] that latencies of greater than 60ms prevent usable collaborative haptics. [Jordan, J. 2002] found that with solid objects a 90 ms round trip latency produced stability issues. However, our work has shown that with specialized physics, in surgical environments with soft objects, round trip latencies of 320 milliseconds can be accommodated. This allows haptic environments to be shared by points on the opposite sides of the globe, and may even permit satellite communications to be used.

2. Plausible Physics

We achieved this by sending all participating forces, including collision impulses, to a single physics 'engine' running a 'pseudo' or 'plausible' physics model. The physics model bears little relationship to reality. However, for our task, the outcome is similar enough to reality to satisfy our needs.

3. Experimental Environment



Figure 1. CSIRO Haptic Workbench

The CSIRO Haptic Workbench uses a SensAble Technologies' Phantom and 3D stereo shutter glasses. We use a mirror arrangement to co-locate the user's visual and haptic experience, without the haptic equipment or user's arm occluding objects in the scene.

4. Surgical Simulation

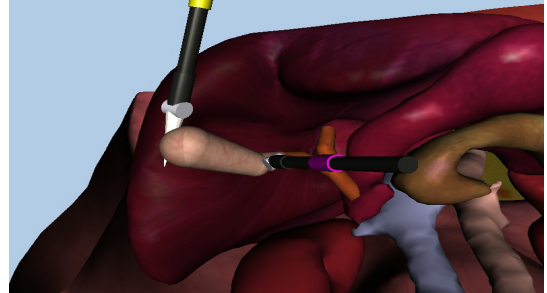


Figure 2. Screen shot of surgical training application

As a test bed for collaborative haptics, we are using surgical training — specifically a cholecystectomy (gall bladder removal). An instructor and student, communicating via a headset/microphone pair, can view, touch and interact with a 3D scene of body organs. The instructor can 'grasp' the student's tool to haptically guide it while the student feels the force of the instructor's guiding hand. Similarly, the instructor feels any resistance caused by the student. They can also collaboratively push, stretch and pull the organs around the scene, with attached body organs stretching and moving accordingly. This system also allows the collaborative viewing and annotation of a video of a real operation and a medical scan. The tool can also leave a 'vapor trail' of fading tool images following the tool motion.

5. Software

The system is a toolkit extension to the Reachin API¹, encapsulating the multi-threading and communications code within two new nodes, which can be simply added to a scene-graph. The nodes create 'remote routes' between corresponding scene objects, allowing changes to be transmitted using either TCP or UDP at rates up to 1000hz.

6. Conclusion

This technology has the potential to allow surgeons in remote or regional areas to connect to experts in any part of the world, for a mentoring session on a particular procedure. The toolkit nature of this system allows this technology to be easily integrated into a range of other application areas.

References

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- STEVENSON, D., ET AL. 1999. Haptic Workbench: A Multisensory Virtual Environment. *The Engineering Reality of Virtual Reality, Electronic Imaging '99*.
- JORDAN, J., ET AL.. 2002. COLLABORATION IN A MEDIATED HAPTIC ENVIRONMENT. *PRESENCE 2002: The 5th Annual International Workshop on Presence*.

¹. www.reachin.se

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This work was carried out under the CeNTIE project, supported by the Australian Commonwealth Government.