One-Dimensional Haptic Rendering Device based on an Audio Loudspeaker

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Overall Goals and Design

- Direct electromagnetic actuation
- Independent force and displacement measurement
- High bandwidth
- Low latency
- Low mass
- Low friction
- Dedicated microprocessor for tissue models with PID control
- Render tool-tissue interaction
- Inexpensive

Optical Measurement of Displacement

- Non contact
- · Lightweight paper reflector
- Infrared LED and sensor





Inductance Measurement of Displacement

- No extra sensor required
- · Inductance of voice coil changes with displacement
- · Measured by introduction of 30 KHz sinusoid
- · Affected by other current in coil used to move speaker
- 2D calibration required



3-Processor Controller

- Free-running Analog Devices microprocessor with A/D and D/A for jitter-free operation at 1 KHz or more.
- Wixel interface processor via Serial Peripheral Interface (SPI), provides USB interface to laptop computer.
- Laptop (slave) computer displays/logs data, provides GUI for controls without interrupting microprocessor.

A. Khera, R. Lee, A. Marcovici, Z. Yu, R. Klatzky, M. Siegel, S. G. Shroff, and G. Stetten, "One-Dimensional Haptic Rendering using Audio Speaker with Displacement Determined by Inductance," *Machines*, Special Issue on Mechanisms and Machinery for Haptic Interaction and Rendering.





