# A Spatial Workbench for Physically-Based Sound

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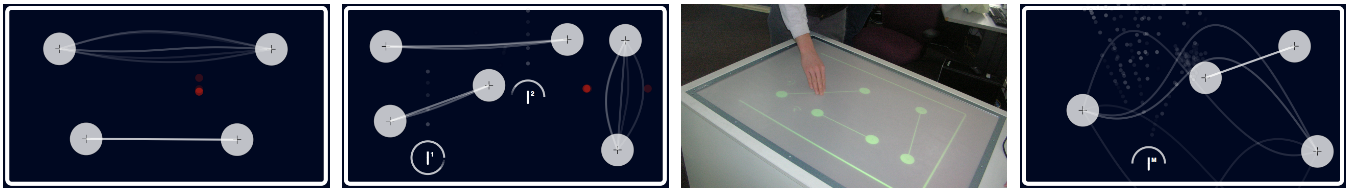

**(a)** *Two strings* **(b)** *Rhythmic particle emitters* **(c)** *In operation on a touch table* **(d)** *Particles sent by a breath sensor*

## 1 Introduction

In this research, we embed physically-based sound models in a spatial, interactive, multi-modal context to make a workbench for exploring new musical ideas. Instruments made with the workbench make sounds that are physically plausible, and they may be controlled in familiar ways, but they go beyond the physical to do things impossible or difficult to do in the real world. Our system outputs both real-time sound and real-time animation in response to users' actions.

Figure (a) shows a simple example involving two guitar strings; the topmost one has just been plucked by dragging the mouse across it. The user of the system sees how the string moves and hears how it sounds at the same time. Plucking at different points and with different speeds produces slightly different sounds and images, mimicking the response of a real string. Pressing in the middle of a string shortens it in a way analogous to fretting a real guitar string. The second string is shorter and so has a higher-pitched sound. Moving the endpoints of the strings changes their lengths and thus their pitches.

We use simple procedural elements to give the system a richer vocabulary and to extend its capabilities beyond the strictly physical. Figure (b) shows rhythmic particle emitters, each of which acts as a kind of active metronome, sending particles which pluck the strings. This might be used to set up a background beat, freeing the user to perform using other parts of the instrument. Furthermore, the design of the instrument itself becomes a locus for performance: the user can change the instrument as it is operating, varying the pitch of existing strings, introducing new ones, or moving things around.

The spatial setting suggests further ideas. For example, multiple strings might be linked together to produce resonance (with a physically-based connection) or sequenced sounds (with a more algorithmic connection). Emitters might rotate or move over time, or respond to various stimuli. Other models, such as bars or plates or even sampled sounds, could be placed in the same space and linked together by either explicit connection or spatial proximity.

The virtual nature of the system suggests ideas as well. For example, a partial mesh of strings might break apart and re-form in new configurations over time, or particles might accrete like barnacles on a string, changing its motion and sound.

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## 2 Multi-modal Controllers

Multitouch input is a natural choice for a system such as the one described here. Figure (c) shows the system being used on a diffuse-illumination multitouch table. In this setting, it is simple to fret and pluck a string at the same time, and multiple people may interact with the same space at once. Using a typical "rotate" gesture on a string endpoint changes its tension as if a guitar tuning key were being turned; the same gesture can be used to place emitters at different angles.

We are also exploring ways to incorporate tangible controllers into the basic touch-based system, giving input that not only specifies a place at a particular time but also a separate varying input level. Simple examples might involve a bend sensor used as a sort of "whammy bar" or a plunger setup used to "blow" particles into the space. An intermediate step is to use sensors that are represented virtually in the space, rather than using tangible objects. Figure (d) shows the result of using a MIDI-based breath sensor to send a field of particles from an emitter.

## 3 Relation to Previous Work

There are many ways to create synthetic sound. Physically-based sound models are both rich in output and controllable in familiar ways. Unlike other approaches, they provide a natural mapping to quantities such as positions, velocities, and forces, making them a good choice for an embedding such as the one considered here.

A physically-based setting for objects, on a touch table or otherwise, is not itself a new idea. Our concern, however, is mainly in the use of space and physics as a setting for the use of physically-based sound models and in the exploration of musical ideas.

Several other systems, including the popular Reactable [Kaltenbrunner et al. 2006], have situated musical objects in spatial relation, and these are certainly an inspiration for our work. The objects in these systems are based on signal processing and abstract notation, and use some spatial ideas in their conception of rhythm and interconnection. Our research uses physically based models and a more concrete, physical notion of space.

## References

KALTENBRUNNER, M., JORDA, S., GEIGER, G., AND ALONSO, M. 2006. The reactable*: A collaborative musical instrument. *Enabling Technologies, IEEE International Workshops on*, 406–411.