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Integration of Touch Pressure and Position Sensing with Speaker Diaphragms

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ABSTRACT

Speaker cones and other driver diaphragms are usually too fragile to be good sites for touch interaction. This can be solved by employing new, lightweight piezoresistive e-textiles with flat, rectangular, stiff surfaces used in full-range drivers from HiWave. Good low-frequency performance of piezoresistive fabric has an advantage over piezoelectric sensing for this situation. Applications of these integrated sensor/actuators include haptic feedback user interfaces and responsive electronic percussion instruments.

1. INTRODUCTION

Sound radiation components of most musical instruments fall within a few inches of the vibrating components and player interactions. Notable exceptions include the organ, the electric guitar and many electrophones. Two practical challenges with electrophone design have frustrated the colocation of loudspeaker and performer interaction: uncontrolled feedback, and large, awkward driver geometries. The first problem is largely solved now that many of the key mathematical and engineering solutions for stable, active feedback are now available—from the scale of musical instruments [1] to the scale of rooms—as illustrated by the Meyer Sound Constellation system. This brief describes introductory forays into the second problem: the colocation of touch sensors with new flat diaphragms.

Rare earth magnets, and compact class-D amplifiers have dramatically increased loudspeaker efficiency at all power ranges. Of particular interest for musical instrument building is the stage at which the space and power efficiency afford drivers that are comparable in size to the human hand. This creates the possibility of electrophones with comparable performance intimacy [4] to traditional hand drums.

The potential of this has already been demonstrated with a haptic drum for stick drumming [2]. This work complements the haptic drum by focusing on the issues with engineering a system to support hand drumming rather than stick drumming.

2. PROTOTYPE

Two drivers from HiWave were chosen for preliminary explorations because they allow for ergonomic layouts similar to those already explored in electronic music such as Don Buchla's Thunder and Hugh LeCaine's Electronic Sackbut. In the exploratory prototype of Figure 1, a 3 inch, HIBM85C20-4 driver is used for palm interaction and the unusually long, narrow, HIBM130H10-6 drivers are used for finger interactions. Both these transducer models have the advantage over conventional cone drivers of having a flat and relatively robust driver surface made of cardboard. They are also full range drivers using the flat surface as part of a piston driver (for low frequencies) and a distributed mode for high frequencies. The drivers are installed in a wooden cigar box that is large enough to support experiments with various porting strategies to boost low frequency efficiency.

With hand drumming, in contrast to stick drumming, it is common for the body to be in contact with the surface for a long time. Therefor piezoresistive transduction was chosen to avoid the problems of poor low-frequency performance of piezoelectric transducers. Two challenges have to be met in their selection: low mass and stiffness compatible with driver material. To judge the impact of the transducer on sound quality one of the three finger drivers is installed without a touch sensor. One of the others hosts a commercial piezoresistive FSR strip from Interlink. The remaining finger driver and palm driver host custom made e-textile resistive sensors. A thin, conductive carbon-based paint is applied to the driver surface to establish the resistive track of a potentiometer. The "wiper" is a silver-plated spandex fabric that floats over the resistive track until pressed down at a contact region. By exchanging the usual roles of the nodes of this 3-node circuit and exploiting the piezoresistivity of the spandex it is possible to measure both pressure and position of touch gestures [3].

Measurements are accomplished using A/D convertors in a microcontroller that encodes them as an OSC data stream over USB to the host computer.

3. PRELIMINARY RESULTS

The basic sensing system works reliably for position sensing. Pressure sensing is complicated, of course, by the interaction between the transducer sound and the applied pressure of the digits and palm. A key requirement of responsive active control is to fix the delay between sensed inputs and actuated outputs. USB support in desktop operating systems is not good enough for this so pressure values will have to be translated into audio input for the computer, a path with controlled I/O latency.

The impact of the sensors on the sound was minor once the FSR lead contacts were properly glued down. Body/transducer interactions on the other hand introduce various timbral changes and buzzes – just as they do with an acoustic resonator. This represents the desired opening into an exploratory space of applications for this haptic hand drum.

Figure 1 Haptic Hand Drum

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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