

# boomBox

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## ABSTRACT

This paper describes the development, function and performance contexts of a digital musical instrument called “boomBox.” The instrument is a wireless, orientation-aware low-frequency, high-amplitude human motion controller for live and sampled sound. The instrument has been used in performance and sound installation contexts. I describe some of what I have learned from the project herein.

## Keywords

Visceral control, sample manipulation, Bluetooth®, metaphor, remutualizing instrument, Human Computer Interaction.

## 1. INTRODUCTION

There have been great advances in both the specificity and sensitivity with which real-time computer music processes can be controlled. Much work has been done to produce real-time software tools which sculpt and mold synthesized, prerecorded and live-captured sound materials down to minute changes in character. A result of this specificity is that hardware interfaces for computer music have necessarily become increasingly sensitive, responsive and consequently somewhat delicate in construction. The responsiveness of computer music instruments would seem at odds with the idea of road-worthy, tough designs for vigorous, or even violent, musical gesture. Few new interfaces for musical expression allow for full use of the dynamic range of human motion, from the lightest tap to the most aggressive movements such as a kick or a punch.

This relatively delicate or precarious design of computer music interfaces is frustrating to some performing computer musicians. At times, both in improvisation and composed performance it is desirable to pummel, mash and heave digital audio material in a hands-on way. The boomBox was built to address this desire.

The boomBox was developed for Gideon D’Arcangelo’s New Instruments for Musical Expression class New York University’s Interactive Telecommunications Program. It was also intended to be a test bed for general instrument design concepts.

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## 2. ARTISITC MOTIVATION

### 2.1 Holistic Design Concept

Many new interfaces for musical expression are designed primarily through the specification of a physical form or gestural property, which is then used to some musical end. Often the physical and/or gestural form of the instrument are intentionally unrelated, or unconcerned with metaphoric or contextual links. Some gesture tracking, reactive environment and other work would appear to employ this approach [1, 2, 3].

The boomBox was purposefully designed iteratively, based in part on a desire to participate in “remutualizing the instrument.” [4] That is, I wanted to pass from physical interface to sound design and back again during design, towards the development of an physical design and sonic output that compliment one another aesthetically and figuratively. This strategy can result in a more holistic performance and instrument exemplar, as sonic attributes become an allegory for the interface or gesture used to create them. Other work which would seem to have benefited from this process are the Helical Keyboard Client (inspired by the cyclic nature of scale systems) [5], the PebbleBox [6] and Pikapika [7].

As of the present iteration of the device, the boomBox is centered around transient sonorities, often described as ‘clanging’, ‘jostling’ and ‘jerking’ of sampled computer sound buffers. The boxy, bulky form and interaction potential of the device categorically suggest such a musical motivation. Here, the re-mix is most literally interpreted, as sample-based material is jumbled together in exciting ways. The completed instrument, which appears to the casual viewer as a typical equipment flight case, is shown being performed in Figure 1.



Figure 1. Performance of the boomBox.

## 2.2 Exceptional Robustness

As Joel Ryan points out physical effort “binds time to the measure of control,” [8] and can be a very important part of expressive gestures. The primary interaction with the boomBox requires a good deal of physical exertion on the part of the performer. This was an initial objective of the project, and takes advantage of what I call high amplitude, low frequency human motion – hitting, kicking, throwing and the like. It was resultantly necessary to ensure that the instrument’s construction was extremely durable. There are of course secondary benefits to such a design requirement, in terms of portability and transportability of the instrument.

## 2.3 Wireless Operation

It was essential that a wireless solution for the boomBox be found as many of the interactions that its form suggests would be impossible were it tethered. This solution was found in the Bluetooth® wireless protocol, a robust and electrically efficient wireless solution for interfacing serial data to most computer operating systems.

A preliminary wired version of the boomBox was made, but upon production of wireless version of the instrument, there were a few very positive unexpected results. The amount that I personalized the instrument increased, as it could be easily brought anywhere with me. Audience engagement within performances improved as there is nothing on stage except the performer and the suitcase, and so nothing to divert attention from the instrument-performer interaction. Also, the wireless design, to an unexpected degree considering the real necessity of a computer and amplification system, gives the impression that sounds are emanating from the instrument itself. I discuss these ideas further later in this report.

## 2.4 Acoustic Sound Amplification

As the boomBox began to take shape and preliminary testing was performed, it became obvious that it would be highly desirable to allow output of the acoustic sound of the box being played. The molded plastic of the box provides an acoustic sound, when struck, which is percussive and slightly resonant. Amplified outside the boomBox, the sound is reminiscent of a contact microphone based work. [9,10]

## 2.5 Leveraging Product Design Principles

In the design of any object, consideration of product and industrial design principles can be helpful. The boomBox emphasizes the notion of affordance, in that it is an instrument constructed from a common object with which most people have some familiarity with. Affordances are “fundamental properties that determine just how the thing could possibly be used.” [11] Like the now notorious JavaMug presented at the Conference on Human Factors in 2001, [12] the boomBox can be approached by musicians and non-musicians alike, as the form of the dialogue between human and object is pre-established. In installation or public exposition contexts, the familiarity of the boomBox as an everyday object allow a degree of *a priori* virtuosity that is enticing. In a more conventional performance situation, the affordances of the boomBox gives the audience a framework for the performance. The performer is likely to pick up a suitcase, put it down, throw it, catch it, et cetera, but not likely to pluck it or blow into it.

Mental models are another product design concept of significance. The standard mental model for the function of a

traditional Western instrument is that the location of sound production and the location of physical interaction with the instrument are coincident. This model is highly obfuscated in most interfaces for computer music by the presence of wiring trailing off to a laptop or sound production unit. Response to the boomBox shows that wireless, unhindered operation of a musical interface can in fact leave standard mental models intact. To many, experiencing the boomBox leaves them with the impression that the sound output is “coming from” the instrument itself. This illusion seems to be at least partially due to the absence of obvious cabling.

## 3. IMPLEMENTATION

### 3.1 Casing & Construction

The boomBox’s superstructure is based on a commercially available injection-molded hard travel case manufactured by Samsonite (shown in Figure 2.). The case, when closed and locked, is water-tight and can withstand almost any human-made force. Every effort was made to preserve both the outward appearance and structural integrity of the travel case.

Inside the boomBox is a form-cut foam padding layer, into which the logic electronics are mounted. All other individual electronic sub-circuits are all contained within smaller cases, themselves packed with another layer of foam padding.

To ensure that the device could withstand even the most punishing physical abuse, all of the electronic and mechanical components inside the boomBox are inbuilt to prevent any movement. Piezoelectric sensors are affixed using epoxy to the inner surface, tilt sensors and accelerometers are mounted in rubber jackets and bolted to the case’s rigid frame. The power supply is wedged tightly in a partition of the case with still more foam padding.



**Figure 2. The boomBox, before, and after, sensor installation.**

### 3.2 Sensor Technologies

The boomBox’s main sensors are piezoelectric polymer strips from MSIUSA [13], conditioned with tuned amplification circuitry, and mounted along the interior walls of the superstructure. These signals are provided as input to audio amplification systems from the boomBox. The system is also equipped with three tilt sensors for orientation data and 2 dual axis accelerometers for motion detection and rotation information. Flex sensors are mounted in the handles of the box, for more subtle, continuous control of musical processes. Finally, a rotation sensor is mounted in the wheel base of the rolling case. Each sensor technology was selected in order to give the overall instrument both coarse and fine control of sonic processes. In particular, the piezoelectric sensor amplification was tuned in a way to allow localized differentiation between areas on surface of the boomBox, and to maximize dynamic range. General functional locations of sensors are diagrammed in Figure 3.



Figure 3. Sensor regions of the boomBox.

### 3.3 Bluetooth® Wireless Link

With due deference to the design principles outlined in 1996 by Perry Cook [12], in the design of the boomBox, wireless was not that bad (compared to wired). Along with a few other recent musical interface designs [14], the boomBox employs the efficient and simple solution of Bluetooth® wireless serial data transfer. A Maxim chip is used to interface the PIC microcontroller to a Bluetooth®-to-RS232 interface from Initium [15]. Data is received on a computer running Mac OS X, which creates an emulated serial port accessed in Max/MSP via the serial object.

The serial data protocol devised for control data relay was made extremely efficient by using unused portions of the 10-bit analog conversion value to encode the sensor ID number. Ultimately, sensor-update latencies within Max/MSP were consistently under 15 ms.

### 3.4 Analog Audio Output

The piezoelectric vibration sensors in the boomBox are provided as analog output as well as being coupled to the input pins for control data. The piezoelectric sensors themselves are amplified using TL082 op amp circuits. These signals are fed to a set of four analog audio output jacks, as well as being coupled to an internal 2.5 V for conversion by the analog to digital converters on the PIC microchip. The signal chain, showing reference levels for control and audio signals is diagrammed in Figure 4.

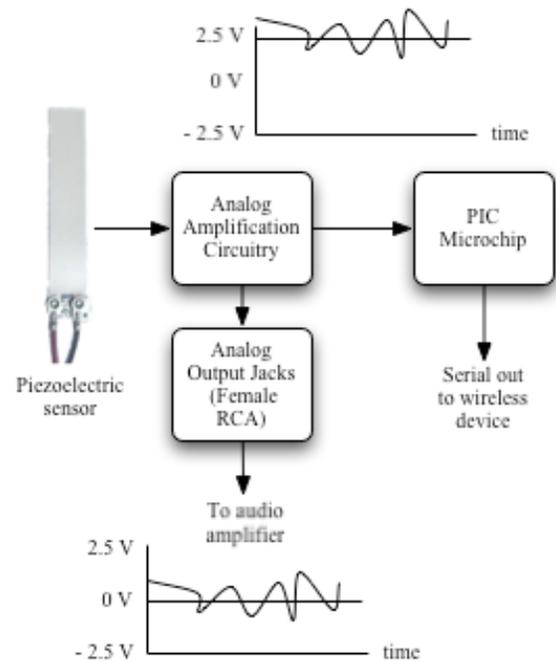


Figure 4. Piezoelectric sensor signal flow for both control data and audio output.

## 4. PERFORMANCE CONTEXTS

### 4.1 Improvised Solo Performance

The first use of the boomBox for performance was at John Zorn's Tonic in New York City. The performance was organized by Gideon D'Arcangelo as part of a showcase of New Interfaces for Musical Expression projects from NYU. I structured the performance very little, and as the instrument was at that time quite new to me, a narrative developed on stage based on exploration of the new device. A picture from the performance is included in Figure 5.



Figure 5. boomBox at the NIME showcase at Tonic, NYC.

### 4.2 Public Sound Installation

Following the Tonic show and subsequent improvised solo performances with the boomBox, I exhibited at the Interactive Telecommunications Program Winter Show 2005. The boomBox was unassumingly arranged in a secluded area of the show space. A four-channel recording of Grand Central Station in New York was looped in the background, "Please do not

leave luggage unattended. Any luggage left unattended will be subject to search and may be destroyed. Thank you for riding the MTA, New York City transit...” For the first time, the political implications related to fear of terrorism suggested by the boomBox were invoked explicitly. Visitors were left to engage the instrument as they wished, in as forcefully a manner as they chose.

Exhibition of the boomBox as an interactive sound installation was an opportunity to witness the many similarities between improvisational performance public interactivity with sound. The engagement that the boomBox provided children and adults alike was akin to the visceral pleasure I experience in improvising with the instrument. A photo of the arrangement of the boomBox in the installation space is shown in Figure 6.



Figure 6. Interactive sound installation presentation of the boomBox.

### 4.3 Dance Performance

A further context for performance I explored with the boomBox was with Pursue the Pulse, a multimedia and dance group. The performance narrative was loosely based on the sound installation presentation of the boomBox. Dance improvisation was done with the instrument, the premise of the performance being that the dancers inadvertently found a piece of left luggage on a subway car. A photo of the performance is shown in Figure 7.



Figure 7. The boomBox in dance performance with Pursue The Pulse.

## 5. ACKNOWLEDGMENTS

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