SCUBA: The Self-Contained Unified Bass Augmenter

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ABSTRACT
The Self-Contained Unified Bass Augmenter (SCUBA) is a new augmentative OSC (Open Sound Control) [5] controller for the tuba. SCUBA adds new expressive possibilities to the existing tuba interface through onboard sensors. These sensors provide continuous and discrete user-controlled parametric data to be mapped at will to signal processing parameters, virtual instrument control parameters, sound playback, and various other functions. In its current manifestation, control data is mapped to change the processing of the instrument's natural sound in Pd (Pure Data) [3]. SCUBA preserves the unity of the solo instrument interface by acoustically mixing direct and processed sound in the instrument's bell via mounted satellite speakers, which are driven by a subwoofer below the performer's chair. The end result augments the existing interface while preserving its original unity and functionality.

Keywords
Interactive music, electro-acoustic musical instruments, musical instrument design, human computer interface, signal processing, Open Sound Control (OSC)

1. INTRODUCTION
SCUBA (see figure 1) began as a class project for a course in human-computer interfaces at the Center for Computer Research in Music and Acoustics (CCRMA) at Stanford University. Its designers brought to the table significant experience in composition, performance, signal processing, and sound recording. The interplay of these diverse specializations led to fruitful discussions that addressed simultaneously the concerns of our multiple areas; our design benefited considerably from this interdisciplinarity.

1.1 Why Modify an Existing Instrument to Create an Electronic Music Controller?
Instruments from the Western Classical tradition are a useful point of departure for designers of new interfaces for musical expression, because they ensure a design foundation that has for some time led to effectively performed music. Additionally, one creates interesting compositional possibilities by designing an augmentation for an existing expressive interface: one can, for example, refer back to the idiomatic vocabulary of gestures and sounds of the base interface while employing the augmentation to change the sonic result of the original interface in musically effective ways. Lastly, an audience of music performed on traditional classical instruments is familiar with these coupling of gestural mappings to sonic results. The sounds, the actions from which they arise, and the sources from which they emanate are known by the audience from the outset—for electronic music controllers, however, this can be less apparent. Thus, a new interface with a link to an existing interface can lend accessibility to a potentially alien concert experience.


Figure 1. A tuba wearing the SCUBA.

Our augmentative controller, although it modifies the instrument's interface in several key ways, aims to preserve as many of the instrument's original features as possible to maximize its accessibility in a performance context.

2. DESIGN GOALS
2.1 Preserving the Functionality and Unity of the Original Interface
Implicit in the statement that a controller is "augmentative" is the preservation of some kind of base interface. With this in mind, SCUBA interferes as little as possible with the existing tuba interface. In fact, the performer can deactivate our controller and play the tuba in its traditional form. The unity of the instrument

interface—that the instrument serves as a locus of both gestural control and sound production—was also seen as essential to the success of our project.

2.2 Design Elegance Informed by Performance Practice

If an effective augmentative controller aims to both preserve the functionality of its base interface and to switch between its base and augmented modes, it is essential that the augmented interface map elegantly onto the existing interface. For this reason, SCUBA takes as a design constraint the traditional performance controls—four piston valves, in this specific case—and playing posture of the tuba. This consideration determined the placement of our continuous and discrete sensors: there are continuous FSR (force-sensitive resistor) sensors on piston valves one and two—these valves are the most frequently used and are played with the strongest and most precise fingers—while piston valves three and four, less frequently used in traditional playing, function only in their regular capacity.

2.3 Design Goals from Compositional Goals

Compositional and improvisational experience within our design group provides a clear sense of the musical structures desired from the augmented tuba. The processing of the instrument's original sound, the preservation of the existing interface, and the current mapping of the interface's controllers in Pd are all in some way influenced by certain compositional goals: the digital creation of circular breathing effects, the ability to create and layer multiple recordings of the instrument's natural sound in real-time, and the addition of timbral effects through the combining of natural and processed sound are musical goals determined by past experience composing for or playing the tuba.

3. THE SCUBA

3.1 Communication Media and Signal Paths

The performer sends discrete and continuous control data to the computer via button and FSR sensors mounted on the instrument. These sensors send variable voltages to analog-digital converters on an AVRmini development board [2] (see figure 2). This digital control data is sent via serial port as an OSC message into Pd, where they are used to control parameters of various signal processing algorithms (the original sound of the tuba is sent to Pd via a microphone into a microphone preamp of the soundcard). Lastly, the processed sound is diffused via the satellite speakers mounted inside the instrument's bell, effectively mixing the processed output with the natural output of the instrument. Figure 4 illustrates these signal pathways.

3.2 Design

The physical design of SCUBA has been realized largely with off-the-shelf parts; although the design team altered some of these store-bought components, little or no custom fabrication was required. The largest component of SCUBA is a commercial 4.1 speaker set, designed for computer audio applications. The set's four slender satellites have been mounted inside the bell for processed output, while its subwoofer powers the satellites from under the performer's chair. This speaker system's remote control has been mounted on the instrument directly in front of the performer to provide a balance control (there is a prominent volume knob). The FSRs and buttons have been obtained from a local electrical components supplier. A slightly modified garage-door opener casing, on the performer's side of the tuba contains a

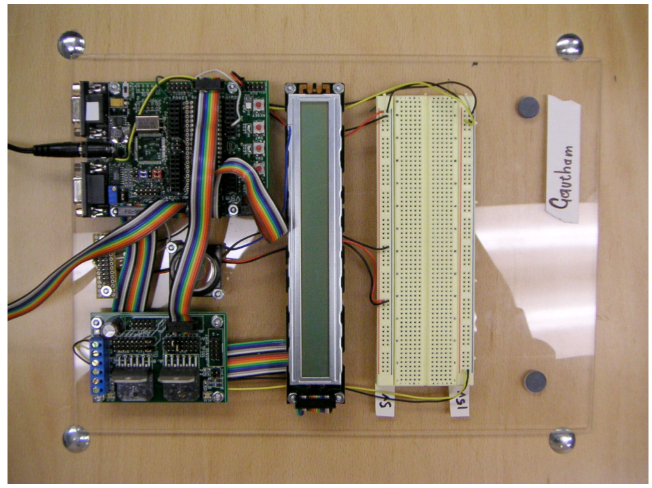

Figure 2. the AVRMini development board.

tuba, contains a solder board on which the individual controllers' data are merged into a single ten-pin ribbon cable, which routes voltages to the AVRmini (see figure 3).

Because the SCUBA interface must be easily removable should the instrument need to appear in more traditional contexts, all components are fastened to the instrument with gaffer tape. In accord with the design goals expressed above, the physical apparatus of the interface is minimized in favor of adding necessary controls to the existing tuba interface.

3.3 Performance Interaction

There are two main components to the scuba interface: the continuous FSR sensors and the discrete button sensors. Continuous controls allow the performer to manipulate parameters of the instrument's timbre. FSR 1 controls the center frequency of a band pass filter that filters the natural tuba sound in Pd, while FSR 2 controls the frequency of oscillation of a low-frequency oscillator. Button 1 provides a discrete timbral control, turning a

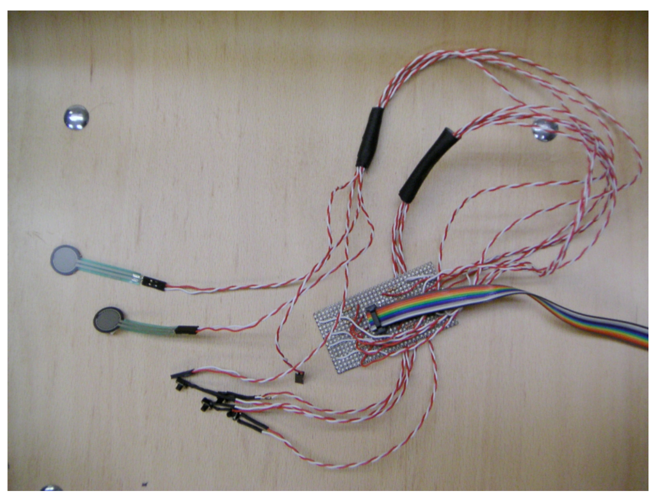

Figure 3. FSR and button sensors are routed through an intermediary solder board, on which their data are condensed into a single ten-pin ribbon cable to be sent to the AVR board.

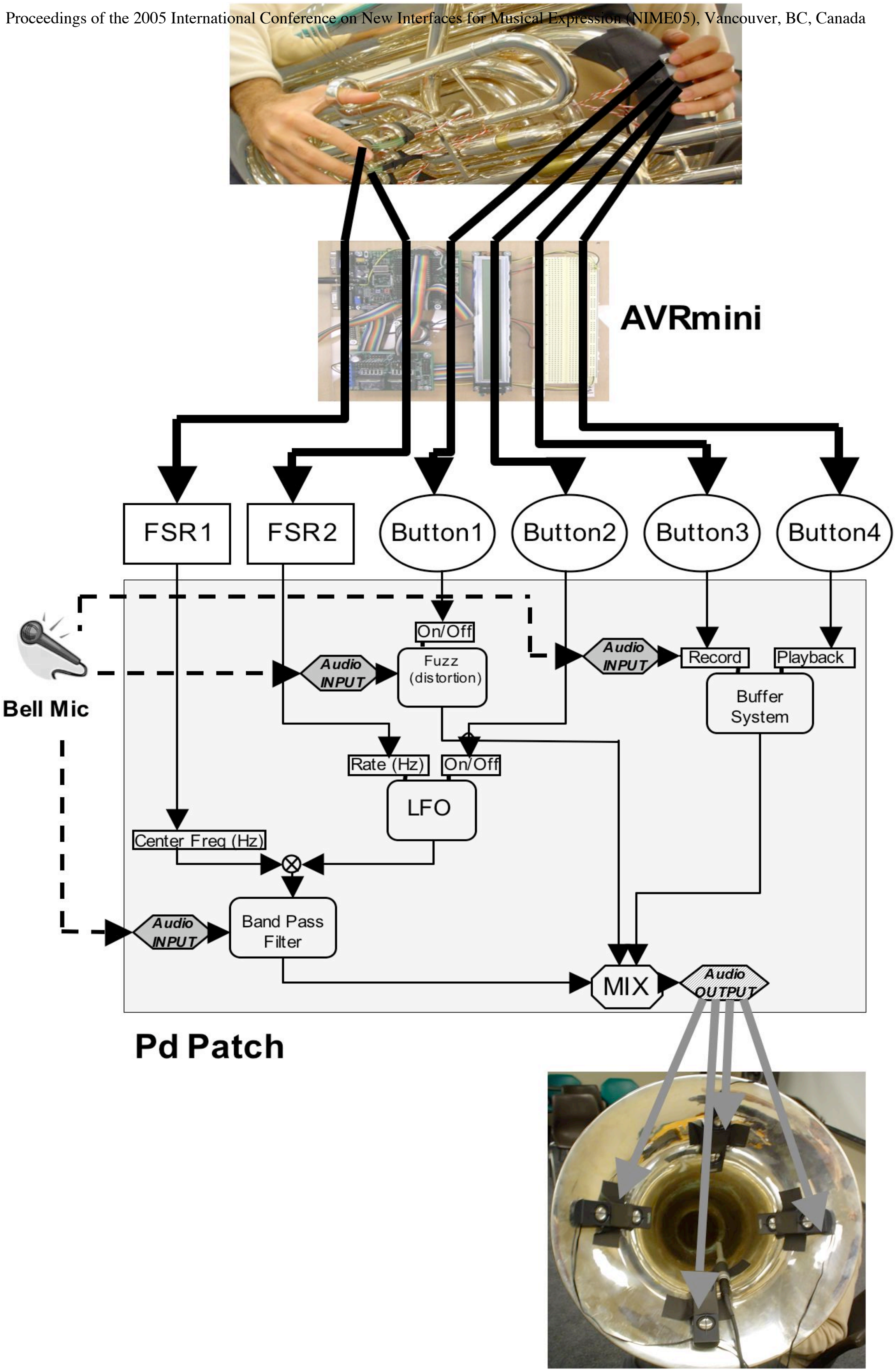

Figure 4. Signal flow through the SCUBA.

simple but effective distortion effect on/off. Button 2 turns the low frequency oscillator on/off. Buttons 3 and 4 provide the performer with a buffer system for the creation of simple polyphonic structures via Pd's buffer sampling capabilities. Pressing button 3 begins recording natural output via the microphone in the bell (pushing button 3 during recording immediately ends recording). After recording, the performer can push button 4 to play back the recorded sample via the bell's output system, while simultaneously producing sound through the instrument's traditional output to create polyphonic textures not previously possible on the instrument. Figure 4 illustrates these performance mappings with regard to signal flow from the instrument, through Pd, to the output at the bell.

3.4 Applications

The SCUBA is intended for use in the live performance of electro-acoustic music. The following URL points to a video that contains design overview by Gautham J. Mysore and several short improvised passages, performed by Jeffrey Treviño, intended to demonstrate the various functions of the SCUBA: http://ccrma.stanford.edu/courses/250a/2004projects/Scuba.mov

Treviño records and layers two lines in real time and demonstrates various harmonic techniques, also derived from such layering, using the discrete controllers (buttons) mounted on the instrument at the tubist's left hand. He demonstrates timbral modifications created by the addition of a low-frequency oscillator to the natural instrument sound, as well as a distortion effect; both of these effects' parameters are controlled continuously in real-time and modally activated using the buttons.

4. CONCLUSION AND FUTURE WORK

As the SCUBA's controller data can be mapped to control parametrically any signal processor or virtual instrument that will accept, convert, and map its control values, future directions for the project will consist of experimentation to personalize the instrument's performance interaction in communication with other virtual instruments according to personal aesthetic preferences.

5. ACKNOWLEDGMENTS

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