The Metasaxophone
Design of a New Computer Music Controller

Matthew Burtner
Virginia Center for Computer Music (VCCM)
Department of Music, University of Virginia, Charlottesville 22903, USA
email: mburtner@virginia.edu

Abstract
The Metasaxophone is an acoustic tenor saxophone retrofitted with an onboard computer microprocessor and an array of sensors that convert performance data into MIDI control messages. The instrument has additionally been outfitted with a unique microphone system that allows for detailed control of the amplified sound. While maintaining full acoustic functionality it is also a versatile MIDI controller and an electric instrument. A primary motivation behind the Metasaxophone is to put signal processing under direct expressive control of the performer. Through the combination of gestural and audio performance control, that employ both discrete and continuous multilayered mapping strategies, the Metasaxophone can be adapted for a wide range of musical purposes. This paper outlines the technical development of the Metasaxophone.

1 Introduction
In 1842, Hector Berlioz (1803-1869) wrote an enthusiastic review of a new instrument, the Saxophone, in the Paris publication Journal de Debats. In it he declared, “We must rejoice that it is impossible to misuse the Saxophone and thus destroy its majestic nature by forcing it to render mere musical futilities (Rascher 1972).” Berlioz, the renowned composer and orchestrator, had been invited by the young Adolphe Sax (1814-1894) to hear his new instrument created to have the widest possible expressive capacities and designed to bridge the divide between the many distinctive timbres and dynamic characteristics of the orchestra. Sax intended his instrument to have the dexterous flexibility of the strings, the coloristic diversity of the woodwinds, and the dynamic power of the brass.

Electroacoustic music creates new possibilities for extending the timbral range of acoustic instruments. Very often, however, the instrumental interface is not suited for direct performer control of these new timbral opportunities. This paper discusses how a project involving music for electronics and acoustic saxophone drove the development of a human computer interface extending the expressive performance possibilities of the saxophone. While the original idea for the Metasaxophone was clear and attainable, it was impossible to foresee the far reaching effects these adaptations would have on performance and composition.
2 Formative Work

The Metasaxophone grew out of an ongoing project exploring the saxophone as an electroacoustic instrument. The project simultaneously pursues extended performance practice and the expansion of the instrument through new technologies. Compositions such as Incantation S4 (1997), Split Voices (1998) and Portals of Distortion (1998) were fundamental in redefining the performance practice of the saxophone and suggesting the Metasaxophone controller. Performance technique took on new meaning in these pieces, becoming a means of opening the saxophone acoustically and exploring its hidden resonant characteristics. All three of these pieces were recorded and released by Innova Records on the 1999 CD, Portals of Distortion: Music for Saxophones, Computers and Stones (Burtner 1999).

3 Redefining the Function of a Key

While performing compositions such as Incantation S4, Portals of Distortion and Split Voices, it became clear that in the context of these slowly evolving musical textures a good deal of the performer's tactile sensitivity was being unused. In each of these pieces, entire minutes may pass with the performer holding down one basic fingering. In the second part of Split Voices, for example, the front five keys are held down for over four minutes while the performer trills other keys and changes the embouchure and air pressure.

A perceived limitation of the manual interface gradually appeared: while the saxophone allows for continuous control over embouchure changes and changing air pressures, the fingers of the performer have very little direct continuous control over the instrumental sound.

It occurred that by giving the keys pressure sensitivity or "aftertouch," a feature common on MIDI keyboard controllers, direct tactile control over the electronic signal processing could be given to the performer. This computer interface could be placed easily in the expressive zone left unused by the instrument, namely finger pressure on the keys. In essence, the saxophone keys which normally execute only on and off changes of the air column, could be converted to continuous control levers. This initial realization led to a vision of seamless integration between the instrumental acoustic and instrumental electronic worlds.

4 Technical Specifications: The MIDI Saxophone

An approach was developed for retrofitting the acoustic Selmer tenor saxophone with sensors and a microprocessor that could convert the performance data into a continuous control data stream. The microprocessor gathers performance data from six pressure sensors on the keys, two pressure sensors off of the keys, five triggers located at different points on the horn, and a sensor for measuring the movement of the instrumental body itself.

![Metasaxophone Block Diagram](image)

Figure 2: Metasax Circuit Block Diagram

Force Sensing Resistors (FSRs), by Interlink Electronics, are located on the front B, A, G, F, E and D keys, and beside each of the thumb rests. Three triggers (also by Interlink) are located on the bell of the instrument and two are positioned on the back, below each of the thumb rests. An Analog Devices ADXL202 accelerometer IC chip on the bell measures the position of the saxophone on a two dimensional axis - left/right and up/down.
The data from these sensors are collected via a twenty six pin serial connector by a Parallax Inc. Basic Stamp BIISX microprocessor fixed to the bell of the instrument. Analog pressure data from the performer is converted to a digital representation by passing each analog signal through a resistor/capacitor (RC) circuit into the input pins on the BIISX. Trim potentiometers calibrate the input sensitivity of each sensor. Figure 2 illustrates the circuit block diagram of the Metasaxophone.

The BIISX is programmed in Parallax Basic (PBASIC) and the software converts the sensor data into MIDI messages. Analog to digital conversion is accomplished using the PBASIC RCTIME (Parallax Inc., 1999) function that measures the charge/discharge time of the RC circuit over time. The Metasaxophone program loops through the input pins reading the RCTIME counter of each pin and the Final Metasaxophone Circuit Board

Multiple programs can be loaded into the BIISX’s EEPROM for a variety of applications. The standard Metasaxophone software sends MIDI control change messages 20-27 on channel 1 for the FSRs, MIDI note-on 1-5 on channel 1 for the triggers, and the accelerometer sends MIDI note-on messages 6-10 as the performer crosses certain thresholds of left/right, up/down tilt, and control change messages 28 and 29 for continuous control.

The continuous controller MIDI messages sent from the Metasaxophone are used to control digital signal processing and synthesis algorithms. Originally an interactive interface programmed in Max/MSP (Zicarelli, 1989) was used. Current developments continue to use Max/MSP but also are exploring interface implementations in James McCartney’s SuperCollider, David Topper’s GAIA Interface for RTCMIX, Max Mathews’ Scanned Synthesis and Miller Puckett’s Pd.

3 Technical Specifications: The Electric Saxophone

The Metasaxophone is a fully functioning tenor saxophone, with all the flexibility and sonic capabilities characteristic of the Paris Super Action Selmer Series II. Since it was assumed that the instrument would be primarily used for electroacoustic music, however, the audio capabilities were also enhanced for electroacoustic music.

In addition to sending MIDI information, the Metasaxophone sends audio signals through small microphones located inside and around the bell. The microphone system was created uniquely for the Metasaxophone and consists of small Panasonic condenser electret cartridges fitted to the ends of bendable tubing and wrapped with the microphone wires inside heat-shrink tubing.

The microphone system is designed to attach to the back of the Metasaxophone circuit box on the top of the bell, and each microphone can be placed independently at the desired location outside or inside the instrument. In the standard configuration, one microphone is positioned deep inside the bell, without touching the inner walls of the instrument. The circuit of this microphone was modified to handle higher sound pressure levels without distortion. Two other microphones are positioned outside the horn, one on the lower half and the other on the upper half/neck area. This configuration allows for close micing of the instruments’ low resonances, high frequencies, and mid-range frequencies. The microphones, however, can be placed in any configuration depending on the application needed, as they are mounted on bendable arms. Each has a separate output allowing the signals to be routed to separate devices for processing or to multiple channels on a mixer. Much thought went into the acoustic design of the microphone system.

As with the MIDI signal, the audio signal is used as a control parameter. By combining the MIDI and audio within a flexible external interface such as Max/MSP, the audio signal can be used to alter the function of the MIDI data or to control other sonic parameters.

The complete interface then allows for dynamic and flexible, multiparametric control. It includes both discrete and continuous control parameters, spatial and force feedback performer interaction with the instrument, and both gestural and audio control variables. Initially the plan was to use these
parameters for one-to-one musical mappings, an idea that had driven the creation of the Metasaxophone. But soon after beginning to experiment with the instrument it became clear that using this interface was like opening an interactive, musical Pandora's Box.

Circular data constructs such as finger pressure controlling audio and audio controlling the effect of finger pressure are idiomatic. Multifunction mappings in which keys control a variety of interlinked parameters were almost unavoidable due to the design of the controller. And the inseparability of the acoustic saxophone interface from either the audio sound or the MIDI control changes, due to the unavoidable changing of key positions, created a highly idiosyncratic but unified controller.

3 Conclusion

The possibilities of new applications for metainstruments are virtually infinite, and this enhancement of the saxophone has pushed the practice of saxophone performance and composition into completely new areas.

The Metasaxophone represents a significant step towards formulating an integrated electroacoustic performance practice. Through the development of embedded systems and sensor technology and the use of general communication protocols such as MIDI, direct control of digital signal processing and electronic processes can be given to the performer. The Metasaxophone has proven a powerful tool for opening new possibilities of real time integration of instrumental and computer music. The addition of multiple layers of continuous control to the saxophone has also opened exciting new directions.

The Metasaxophone furthers Adolphe Sax’s vision of an instrument combining the timbral and expressive characteristics of the orchestra by uniting the saxophone with the world of the computer orchestra.

4 References


