Expanding the saxophone with different tone generators and a foot controller for complementary voices

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ABSTRACT

This paper focuses on expanding saxophone performance practice through exchangeable tone generators and a foot controller utilizing fine motor skills. The combination of both expansions extends the timbral qualities of the saxophone into new territories. The different tone generators turn the saxophone into a flute, a sarrusophone, a modern variation of the Renaissance cornett, and a free-reed instrument with each instrument class's distinct sonic characters. The foot-controller system consists of a trackball operated by the big toe of one foot with separate pedals to simulate the mouse buttons with the other foot. The system also includes a traditional MIDI bass pedal, an expression pedal, and a wide-spaced ASCII keyboard. In particular, the trackball system enables complex timbre changes and a flexible processing flow needed for freely improvised music. It can be used to control a complete personal computer. The learning curve to develop the feet's fine motor skills is comparable to learning new embouchures for the different tone generators.

Author Keywords

extended saxophone techniques, foot controller, fine motor skills, free improvised music

CCS Concepts

•Human-centered computing → Human computer interaction (HCI)
• Human-centered computing → Accessibility

1. OVERVIEW

This project to expand the sonic richness of the saxophone was inspired by Pauline Oliveros' (1932-2016) concept of the Expanded Instrument System (EIS) [1]. EIS is a live performance system based on random event generators that control multiple delay lines, loopers, and sound spatialization tools among other features. Oliveros typically used it in conjunction with her Roland Accordion Synthesizer, which recreated the sound of many musical instruments using a physical modeling algorithm. A central part of Oliveros' EIS system was a foot controller with several expression pedals. Over time, the author had several opportunities to perform and record with her and felt afterward that the saxophone's tonal capabilities were too limited [2, 3]. Consequently, he developed several tone generators for the saxophone to expand the sonic spectrum of the instrument – see Section 2.

With her EIS system, Oliveros intended to augment the accordion and provide the instrument with abilities it naturally does not have, such as pitch bends in particular. The EIS system is both an instrument expander and a simulated environment with an audio spatializer and reverberation. Oliveros controlled the EIS system's numerous parameters with foot controllers, so she had both hands free for the accordion interface. She was so eager to control as many parameters as possible that she dived deeply into assistive technologies to learn from the "most marginalized" people, as she put it. The AUMI instrument she developed out of this engagement is still in use today [4, 5].

The author's idea of using foot pedals is derived from Oliveros' concept but follows an alternative approach that provides more flexibility. Inspired by disability studies, the author noticed that we do not use foot pedals to the most ergonomic extent. Traditional foot pedals and organ pedal keys are typically played with shoes on, which is like playing a wind instrument with mittens. Nobody would do this unless it is winter and one is playing trombone in a marching band. Our culture neglects the development of the feet's fine motor skills.

2. MODIFYING THE SAXOPHONE WITH DIFFERENT TONE GENERATORS

The idea of exchanging tone generators of wind instruments has been frequently discussed but not thoroughly followed through, most likely because it requires several years of practice to master different tone generators. Stuart Dempster, for example, writes on Page 12 in his classic trombone book: "Composers would be wise not to ask for specific pitches or chords from these assemblages [oboe, bassoon reeds, and saxophone mouthpieces], since in the hands (or in the mouths) of trombonists, they normally lack control." [6]. This challenge, however, can be overcome with a careful adapter design and practice. The best early example of tone-generator substitution in wind instruments is probably Eddie Harris' reed trumpet, a trumpet modified with a saxophone mouthpiece so it can be played with less embouchure fatigue [7]. The practice described here goes well beyond Harris' approach by using a collection of eight different tone generators to expand the timbral qualities of a soprano saxophone, as shown in Figure 1 and thoroughly described in [8].

Figure 1. Different tone generators adapted for the soprano saxophone (from left to right): bawu-reed adapter, bassoon reed with adapter, regular saxophone mouthpiece (Otto Link, 13*), and an adapter for the cornett mouthpiece (C. Monk mouthpiece by Jeremy West).

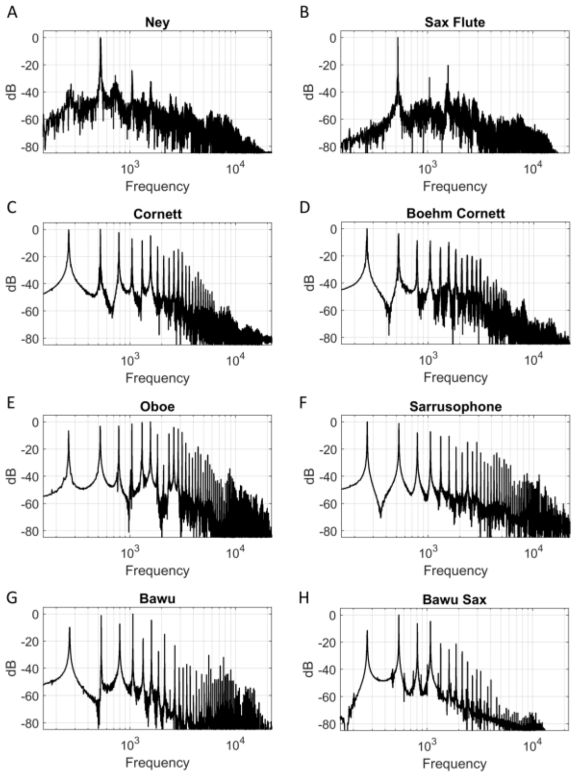

Figure 2. Frequency spectra for four different saxophone tone generators (right column, from top to bottom): Saxophone played as rim flute, saxophone with modified cornett mouthpiece (Boehm cornett), saxophone with bassoon reed (Sarrusophone), and saxophone with bawu reed. The left graphs show the frequency spectra for the prototype instruments (from top to bottom): Turkish ney, Renaissance cornett (modern copy by Moeck with a mouthpiece by Jeremy West), orchestral oboe (Yamaha), Chinese bawu.

All saxophone variations can be played in tune over the range of the prototypical instruments (not shown): flute (2 octaves), cornett (2 1/2 octaves), bassoon-reed (2 octaves), bawu-reed (1 octave plus a whole note and two additional under-blown notes, which is basically the range as the original bawu). It should be noted that the characteristic tone generators can be heard out for all instruments. These sonic features are observeable in the spectra, as shown in Figure 2, but could be depicted in an onset analysis that would go beyond the scope of this paper.

For example, the saxophone with a cornett mouthpiece can be perceptually identified as a brass instrument, and it no longer sounds like a woodwind instrument. The expanded saxophone incorporates traits of the whole wind instrument corpus rather than just imitating their sounds. It can no longer be classified into one distinct category because the commonly used classification system after von Hornbostel and Sachs [9] primarily classifies musical instruments according to their tone generators -- see Figure 3.

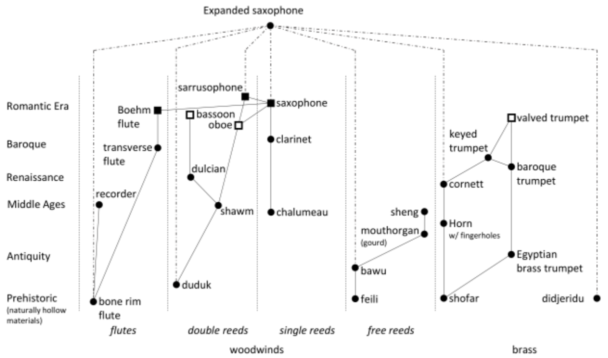

Figure 3. Influences of the expanded saxophone as functions of instrument category (x-axis) and time (y-axis). Filled circles show predecessors and filled squared depict current orchestral instruments. Lines depict evolutionary linkages between these wind instruments.

3. A FOOT CONTROLLER CAPABLE OF FINE MOTOR CONTROL

Foot pedals are often used to augment a musician's performance ability because her hands are too busy to operate additional functions by hand [10–14]. Based on the demands of the author's music practice, which is largely timbre and texture-oriented, the author decided to develop a foot controller that allows for fine motor control. The device was inspired by artists with disabilities who use their feet to play music and have demonstrated that one can gain similar fine motor control with the foot compared to our fingers' control. Felix Klieser is a virtuoso classical horn player who, being born without arms, operates the valves using his foot [15].

The center of the assembled controller is a regular trackball interface that is used as a mouse substitute – see Figure 4. The trackball is rolled with the left big toe, and since it is difficult to press the "mouse" buttons at the same time, the left and right buttons are substituted from a transcription foot pedal system used by stenographers (Grundig, Stenorette 526A). The pedal's electronics were hacked by soldering the analog controller to a spare circuit board of a mouse interface, which was glued inside the pedal. This system's advantage is that no software application is required to map the pedal output into mouse button commands, as is sometimes the case with commercial USB foot pedals.

After some training, the trackball interface can be used intuitively, for example, to write "foot"-written notes – see accompanying video https://vimeo.com/943877077]. With additional training, one can probably avoid writing like a first grader, but for the control of music parameters, this skill is not necessary. An ASCII computer keyboard with wide inter-key spacing is located in between both controllers (Grandtec, Virtually Indestructible Keyboard). The foot-controller system also includes a velocity-sensitive MIDI bass pedalboard (Ketron K8) and an expression pedal (Behringer FCV100). The virtually indestructible ASCII keyboard is even exhausting to operate by hand, but it is easy to clean and good enough to type small texts such as URLs using the big toes.

The foot-controller system shown in Figure 4 allows great flexibility, and it can be used to control the entire computer. The author's improvised music practice draws on long notes and passages with circular breathing over several minutes, and the controller allows the author to assign new parameters and develop new concepts on the fly. Example scenarios include:

1. Controlling a virtual analog synthesizer where cords can be patched by foot as needed, and the virtual controllers can be operated using the trackball.
2. DAW operation.
3. Virtual Orchestra using a sampling library.
4. Controlling Pauline Oliveros' Expanded Instrument System (EIS).

Figure 4. The proposed foot-controller system consists of a trackball (enabling fine motor control), mouse buttons, an expression pedal, and a MIDI bass keyboard pedal.

In general, the author is more interested in augmenting the natural tone of the saxophone rather than processing it, as is the case in Oliveros' EIS system. (S)he often treats his/her expanded saxophone system as a combination of saxophone, foot controller-enabled counter-voice, and joint sonic environment.

4. DISCUSSION

Using the foot-controller requires two different training types, one regarding the operation of the foot controller itself, and the other one to learn to coordinate between hand and foot movement. Learning to operate the controller itself is a question of training and time. In the beginning, this can be very fatiguing, and it was important to design a footrest for the heel to improve the ergonomics. For those who have a good memory in their elementary-school childhood, learning to develop fine motor skills in the toe is similar to learning to write by hand. The results that were shown in Image 5 support this comparison. Training will require time, and it is usually better to train often and continuously rather than in overly long sessions. The author had similar experiences when learning to perform the different mouthpieces for the saxophone. Like hand-writing, once the motor skills have been developed in the foot, regular training is not necessary to retain the motor memory.

Learning to coordinate between the hand and foot movement can be the more challenging part [16]. Fortunately, much literature exists on this topic one can draw from pipe organ [17, 18] and piano literature [19]. Performing the pipe organ might be the most challenging task because it requires the coordination/independence of the left and right hand as well as the feet. Bach's pieces are known to be compelling because they often incorporate three independent voices. In contrast, the piano requires the independence of the left and right hands, and no additional voices are played using the feet.

Like the piano, the music practice described here basically requires the coordination of two independent sections: (i) the saxophone and (ii) voices played by the foot controller, and studying the piano literature can be helpful, especially when learning to play counter melodies using both instruments. Non-traditional use cases for the foot controller, such as operating a DAW or live coding, can have lesser requirements concerning timing as these operations are often not as timing-sensitive as playing notes. This can be leveraged against the additional training requirements for the feet's fine motor skills.

Figure 5. Example of using the trackball as a foot controller to write.

5. CONCLUSION & OUTLOOK

The paper described a fundamentally new foot-controller concept utilizing the feet's capabilities of fine motor control. The interface was inspired by assistive technologies and experts who developed fine motor skills using their feet to compensate for disabilities. By applying their insight outside of disability studies, an adequate foot controller was developed to augment the author's largely texture and timbre-based wind instrument practice. Combining the new foot controller with a unique saxophone practice that draws from exchangeable tone generators provides new dimensions in tonal flexibility for wind instrument practice. The concept can be easily applied to other (wind) instruments and music practices.

6. ETHICAL STANDARDS

The research presented here followed the guidelines of the NIME Principles & Code of Practice on Ethical Research (1.1) [20].

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