The Bass Sleeve: A Real-time Multimedia Gestural Controller for Augmented Electric Bass Performance

Izzi Ramkissoon
New York University
34 West Fourth St.
New York, N.Y. 10012
IzzRk@aol.com

ABSTRACT
The Bass Sleeve uses an Arduino board with a combination of buttons, switches, flex sensors, force sensing resistors, and an accelerometer to map the ancillary movements of a performer to sampling, real-time audio and video processing including pitch shifting, delay, low pass filtering, and onscreen video movement. The device was created to augment the existing functions of the electric bass and explore the use of ancillary gestures to control the laptop in a live performance. In this research it was found that incorporating ancillary gestures into a live performance could be useful when controlling the parameters of audio processing, sound synthesis and video manipulation. These ancillary motions can be a practical solution to gestural multitasking allowing independent control of computer music parameters while performing with the electric bass. The process of performing with the Bass Sleeve resulted in a greater amount of laptop control, an increase in the amount of expressiveness using the electric bass in combination with the laptop, and an improvement in the interactivity on both the electric bass and laptop during a live performance. The design uses various gesture-to-sound mapping strategies to accomplish a compositional task during an electro acoustic multimedia musical performance piece.

Keywords
Interactive Music, Interactive Performance Systems, Gesture Controllers, Augmented Instruments, Electric Bass, Video Tracking

1. INTRODUCTION
In the past, when working on developing a performance setup to combine both live electronics and a string instrument the focus has been on extending traditional technique by using gesture acquisition based on existing relationships between the performer and string instrument. The use of existing gestures, in regard to the common practice of string instrument technique, has led designers to use instrumental gestures to control electronic sound. It is important to maintain the technique that many performers have developed over years of practice, while still being able to control the electronic aspect of the performance. This method to instrument augmentation has led to many systems in violin, cello, acoustic bass performance.

2. THE BASS SLEEVE
The design of the Bass Sleeve allows for a performer to control expressive parameters of a sound using motions other than hand to string relationships. In the design, ancillary gestures such as forward and backward foot motions, knee movement, knee bending, and quick hand gestures were used to extend the range of expressive gestures within the performance of an electronic electric bass performance. In the context of a performance, these motions create metaphors of tension and release that shape the sound viscerally, communicating qualities of effort to the audience, while extending the range of expressive gestures. The design of the hardware interface augments the gestures of the electric bass and increases the independent control over sound processing creating a variety of new gestural relationships for bassist.

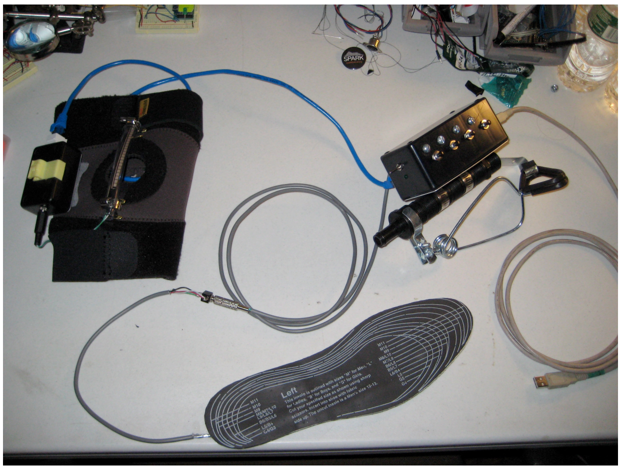

Figure 1: Bass sleeve full system prototype including the knee controller, foot controller and control box.

3. HARDWARE DESIGN
The Bass Sleeve incorporates both a knee mounted controller and an insole for foot control. Both of these parts of the controller use ancillary movements to shape the sound in a real-time electric bass performance. The movements that were selected are outside the range of effective gestures when controlling the sound of the instrument. In a situation where an electric bassist performs with a laptop it becomes difficult to continuously control both the laptop and the bass with only two hands. This might seem a bit obvious but many times a controller is made to interrupt an expressive performance with additional gestures that have nothing to do with an expressive performance. The gestures introduced into the performance control something other than the actual sound of the instrument creating additional gestures that lower the communication of expression during a concert. A solution to incorporating controls and maintaining the level expressivity in a performance can be seen with the addition of ancillary gestures on pre-existing traditional gestures. This approach is an

alternative to using traditional technique as gestural controls and is explored with both the knee and foot controller.

3.1 The Knee Controller

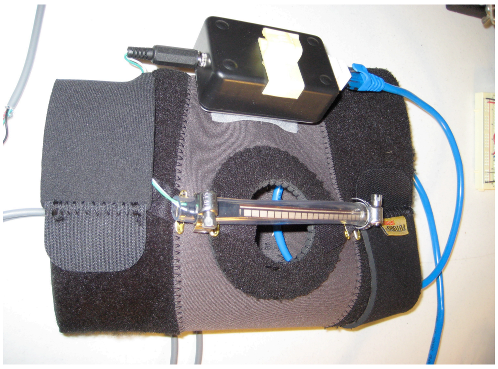

Figure 2: The knee controller uses a bend sensor and accelerometer.

The knee controller is made using a knee brace, a flex sensor, accelerometer, safety pins, clear tubing, Velcro, Ethernet port, small black project box and clamps. The flex sensor is inserted into a plastic tube to act as a buffer. This relieves some stress from the bend sensor during a performance. In a previous test the performer would bend the knee rather aggressively sometimes either breaking or overloading the sensor causing loud pops and crackles interrupting the sound with unwanted digital artifacts. With the addition of the plastic tube the stress that occurs with the bending of the knee is dissipated throughout the material allowing the bend sensor to bend freely within the durable tubing. The tube is attached to the knee brace using clamps and safety pins. This makes it easy to replace worn bend sensors while having a durable form. The bend sensor output uses an 8^{th} inch jack making the input modular. The entire system follows the idea of being modular allowing customization for each individual performance or composition. On the side of the knee is a small black box that houses the accelerometer. The bend sensor output is connected at the bottom.

The accelerometer on the side of the knee and is used to map the motions of the knee through space. The placement of the accelerometer allows accurate x, y, and z control. Velcro and a safety pin are used to fasten the box to the side of the knee. In the development of this system it was found that Velcro could be used to affix many sensors, although when performing sweat moisture can create problems with sensor placement. This led to the addition of a safety pin to ensure that there would be no movement of the sensor.

3.2 Insole Foot Controller

The second part of the bass sleeve was the foot controller. The foot controller is made using two force sensing resistors, hot glue, wire cable, port and a shoe insole. The FSR wires are hot glued to the surface of the shoe insole. The hot glue is used to both insulate the wires from sweat and secure them to one place on the insole. The insole has a port to insert the FSR making the sensor easy to replace. The output from the FSR wires is a stereo 8^{th} of an inch jack that can be extended to the control box using a stereo cable. After all the cabling was finished both the left and right insoles were glued together to create a buffer between the foot sensors and shoe.

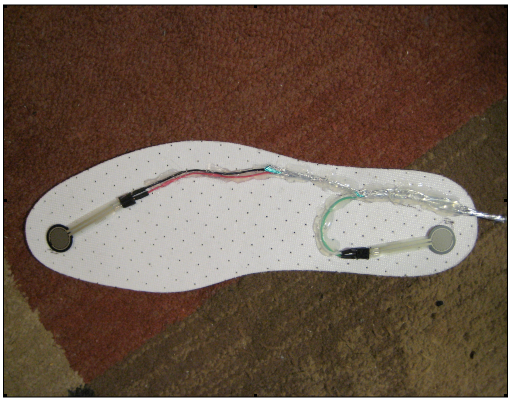

Figure 3: Foot controller using two FSR's.

The foot controller adds the possibilities of sensing the weight distribution of the leg from front to back. This led to the placement of sensors at the front toe and back heel for weight distribution. Also, when in resting position the weight was neither all the way on the toe nor on the heel but evenly dispersed around the foot. This relationship will be explored with various mapping strategies. In tandem both the knee controller and the foot controller acquire the motions of the leg either thrusting forward and down, back and up, side to side or any combination of these motions. Both can be easily detached or attached in any giving performance making it very modular for many different types of mappings.

3.3 The Control Box

The control box was made to attach onto the bottom of the bass visually linking all of the sensors on the leg to the actual bass. The box placement was important for both aesthetic and functional reasons. Having the box in visual site attached to the bass creates the sense of augmenting. In the past, augmentation many times comes with the sensors all over the performance area of the instrument. This was more of a subtle solution to connecting the two worlds. It also serves as part of the controller with buttons for mode selects. This shortens the distance needed to travel to press a key and is smaller than a foot controller because of the form factor of the hands. The box is used in performance that same way any other tone control on your bass would be used only this controls both tone, texture and video.

Figure 4: The control box mounted to an electric bass.

The control box is made using a medium size project box, switches, buttons, plastic pipe fixtures, clamps, Arduino mini, Arduino to USB, Ethernet port, 8^{th} inch stereo jack and a light clamp. Inside the box an Arduino mini microprocessor is used connect to a mini USB adapter. The Arduino mini has 8 analog inputs and 12 digital inputs. The control box has 4 wired buttons hardwired to the microprocessor with the possibility of expansion to 8, if needed. The controls are used to turn devices on and off, shuffle through modes, and set levels.

3.4 Video Tracking

Elements of video tracking were used in the software patch to gather information about the position of the performer. Many times sensor-based instruments localize parts of the body gathering small movements. The Bass Sleeve incorporates both small and large movements using the body-mounted sensors to capture very small gestures and video tracking to capture larger gestures. When performing multiple tasks in a live performance it is hard to think about performing on an instrument, processing the sound of your instrument and then controlling video real-time. The video-tracking patch creates an algorithmic relationship between the performer's place in space and video processing. The video processing mappings were, the closer a performer gets to the camera the larger the processed visual gets, the greater amount of side-to-side movement produces variations in the horizontal placement of the image.

4. ANCILLARY GESTURE CONTROL

In the Bass Sleeve project ancillary gestures were mapped to sound synthesis and processing. The main goals of this project was to delve into the possibilities for gestures other than traditional playing technique, effective gestures, and accompanist gestures to control sound parameters in a live electric bass performance. The use of ancillary gestures in live performance to control sound has played a minimal part in the creation of modern electronic music, even more so the relationship between expressive gestures and sound. It was found that in a performance the ability to show effort and create tension and release through a gesture was an effective way to communicate expressive musical qualities such as pitch shifting, timbre manipulation, stutter and drone effects. The methods that were used to create the tension and release in the sound were body motions that had the same qualities such as the bending of the knee and foot pressure. The ability to use effective, accompanist and ancillary gestural control shaped the performance into a full body expressive instrument is important when developing an expressive full range controller.

4.1 Ancillary Gesture Mapping Strategies

Table 1. Bass Sleeve Mappings

Front foot FSR – pitch shifter
Back foot FSR – sampling
Knee bend sensor – low-pass filtering
Knee Accelerometer X – synthesis pitch
Knee Accelerometer Y – synthesis LFO
Knee Accelerometer Z – synthesis LFO
Bass Box 1 up – drum volume
Bass Box 2 up – drum phase start
Bass Box 3 up – video tracking enable
Bass Box 4 up – mounted sensors tracking enable
Bass Box 1 down – Bass Sleeve ON/OFF
Bass Box 2 down – delay repeater
Bass Box 3 down – delay feedback
Bass Box 4 down – filter select

These mappings were determined in the initial experimentation of the design. The design of the mappings was based on the relationships between the motions of the body and the compositional process that it would control. The front foot, in the first set of mappings, was made to trigger the sampling of the electric bass and the back heel was mapped to pitch shifting. This was an experiment with the mappings and not the intent of the original design. It was found that the back heel did not communicate as much effort and tension as the front foot did when using pitch shifting. It was also found that the back heel used for pitch shifting created a tiresome performance practice that was difficult to maintain over an hour performance. These mappings were reversed and put back to the original concept, which was to use a downward thrust to signify to the audience and fellow performers that effort was being put into pitch shifting the sample. The downward thrust with pressure on the front foot was effective in communicating this particular sound. The performance gesture that was used shifted pressure from the front of the foot to the back of the foot processing the sample with foot pressure. This process produced variations in sampling and pitch.

One of the mappings used in the programming of the Bass Sleeve was low pass filtering to the amount the knee bent. The choice to use low pass filtering was an important compositional decision. The relationship between the effort used to bend the knee and the sound processing created a metaphor of tension and release within the performance. When experimenting with the knee sensor it was also mapped to pitch shifting which produced a meaningful relationship as well. The relationships that related most to the knee gestures were those that had the similar qualities of tension and release such a speed control, scrubbing, clean to distortion, but in the end low pass filtering had a relevant quality that was desired in the overall signal flow of the Bass Sleeve. Alternative mappings can be used in the knee depending on how a composer wishes to form relationships between the controller and sound.

The knee controller contained an accelerometer. The accelerometer was mapped to sound synthesis controlled by both the knee and the pitch of the bass. The sound synthesis was at the top of the signal flow so that the low pass filtering could process it. The mappings of synthesis to the knee were a novel approach to the controller, which sounded better than it looked.

The mappings used in the control box can be re-mapped depending on the important parameters, functions, events, and mode selects in any given composition or improvisation. A performer can determine beforehand the necessary quick controls and map them to the control box, allowing more control away from the computer and closer to the instrument.

5. SOFTWARE

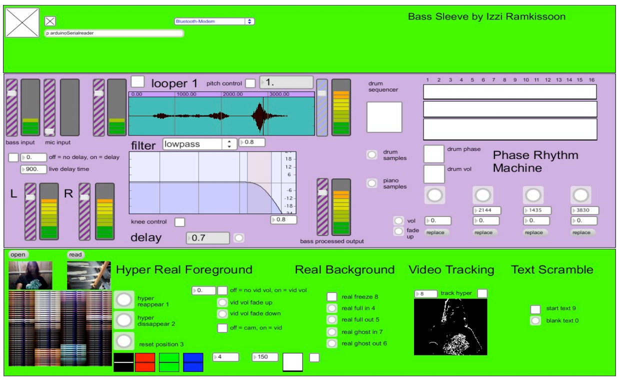

Figure 5: Screenshot of the laptop screen during a practice session with the Bass Sleeve system.

The bass sleeve system was designed for composition and live performance. The software was designed for a specific direction in composition. The programming developed to explore methods to develop a small looping sample with delay, filtering, pitch shifting creating granular clouds and stutter effects. This was in response to the current state of loop-based performances. Many electronic musicians use looping devices to create live electronic music. The ability to loop gives the performer and composer the ability to create layers on layers of musical material. The issues in this type of composition are the process in which composer develop static loops to produce variety. Many time loop compositions take the form of adding and subtracting layers with little manipulation of the sample loop itself. The approach to looping in the Bass Sleeve programming allows a small loop to have life outside of repetition by processing the samples sound over time. The interest in developing the sample using certain techniques came from the exploration of digital manipulation in earlier compositions including pitch shifting, sample speed, filtering and delay. In electronic music the use of repetition can be seen in pieces such as Steve Reich's Electric Counterpoint or Terry Reilly's in C. The use of effects to create repetition has also played an important role in modern music. Much of these ideas were the inspiration for the programming.

6. CONCLUSION

In the development of the Bass Sleeve it was found useful to use ancillary gestures for music control. These extra gestures give independence to one-to-one and one-to-many mapping strategies allowing a musicians complex control away from instrumental gestures. The combination of both traditional electric bass instrumental technique and computer control can be difficult when performing. The Bass Sleeve introduces a novel solution to performing with an electric bass and the laptop by controlling and manipulating processed sound in live performance situations using ancillary gestural control. It was found that small gestures could be used with the hands similar to the motion to turn a volume potentiometer or flip a pickup switch and larger gestures such as side-to-side movement for audio and visual panning. Incorporating ancillary gestures into performance technique allows for a more expressive full body performance based on the increase in interaction a performer can have with an audience, other performers, the laptop and traditional instrument. The goal of this system is to approach the realm of having a seamless relationship between the performer-to- instrument and performer-to-computer, with the relationship being performer-to-overall instrument.

7. FUTURE WORK

In the future version of the Bass Sleeve augmented instrument design some of the hardware issues such as sensors slipping, sensor selection, durability and reliability on the knee gestural controller will be redesigned to increase its performance in live musical applications. The redesign will include an exploration in alternative options to sense the bending of the knee other than a bend sensor, other options to mount the bend sensor to produce a greater amount of durable and reliability, and the possibility of additional programming to compensate for sensor erratic input when a sensor slips or is overloaded.

The application of the knee bending gesture to sound will be explored further since the mappings were specific to the current composition. In the future version, a database of different modes, functions and compositional approaches will be programmed to allow the Bass Sleeve to have a variety of relationship to express during a performance. The database will include different sets of processing that all relate to each other with a modular approach to programming allowing the user to experiment with different signal chains. The system will also have a modular approach to hardware design allowing for additional ancillary gestural hardware attachments.

In addition to the redesign and redefining of the system through mapping, a greater amount of compositional techniques will be explored in the future work with the Bass Sleeve. Some specific techniques that will be explored in the Bass Sleeve will be relationships between audio and video processing and mapping such as live input amplitude mapped to the visual pillars, methods to analyze and synthesize the bass sound creating counterpoint lines using MIDI, the processing of synthesized counter point lines during a performance by a gesture using filtering and LFO, the mapping of independent layers or counterpoint lines to specific ancillary gestures to form relationships to the live electric bass and the programming for real-time improvisation.

The future of the Bass Sleeve system will be for personal use since many of the concepts still need to be tested in a live performance setting. In the redesign of the interactive performance system certain standards of usability must be met before other musicians can use the system. The controller will have to support a very general approach to satisfying the performance needs of any electric bassist before can be introduced as a device for public use.

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