BA Hons Creative Music Production

Professional Project

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# Gesture-Based Audio Manipulation

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## Abstract

This project aims to answer the research question, “Can real-time gestural control of effects enhance a live performance?” Work already done in this area will be analysed to provide guidance for the design and implementation of a gestural control interface, which will be utilised in a live performance. A survey was created, and the answers were from viewers of a performance. The data collected from this survey was analysed and has been used to answer the research question. The implications of this result will be discussed, and further work in this area will be explored.

## Introduction

This project seeks to answer the question, “Can real-time gestural control of effects enhance a live performance?” A hand-sensing program tailored to control effects will be created. A Leap Motion Controller 2 will interface with a computer to manipulate audio effects. The computer will be running a programming language called Pure Data. The Pure Data program will house effects manipulated by the interface. The resulting interface will allow the user to control audio effects with their hand by utilising various gestures. The sections covered in this thesis are as follows: a literature review looking at the hardware and software that will be used and research on the impact of the instrument. This will be followed by a methodology section influenced by the literature review, which will look at the various methods used for collecting feedback and data regarding the usability and design of the project, a prototype that was used for testing. The feedback and data will be analysed from the performers' and user testers' perspectives to influence design decisions throughout the project lifespan.

# Literature Review

## Introduction

In this literature review, the design and intent of a gesture-based audio manipulation tool will be looked at under three main headings: impact, hardware and software. The literature will provide insight into how the hardware and software works. The impact section includes principles and previous work in these areas that will influence decisions made throughout the project's lifespan. From now on, the gesture-based audio manipulation tool will be called the interface.

## Impact

### What Makes a Good Musical Instrument

In work done by Rodger, Stapleton and Walstijn, the concept of what makes a good musical instrument was explored. The research looked at instruments as a whole, not talking about electronic, acoustic, or any other type of instrument, just instruments in general. The principles and results in this paper will lead the design process of the interface in this project. The section below is under some of the same titles put forward by Rodger, Stapleton and Walstijn.

### Instrument-as-Device

The first principle put forward is extended technique. Extended technique is "a non-traditional way to produce sound from an instrument." (Lunn). This is the concept of using an instrument in a way the designer does not intend. One example of this is playing the piece of string that is between the body and the bridge on a Fender Jazzmaster. This produces a different tone to striking the strings directly. Some players minimise this ringing by putting foam between the strings; others see it as the signature Jazzmaster sound.

Another aspect of an instrument-as-device is instrument resistance. Instrument resistance is the concept that "the effortful-ness of playing an instrument may be a source of creativity and animation of performance." (Rodger, Stapleton and Walstijn). This is the concept that by virtue of the effort put into an instrument, it can be an impactful performance piece. The difficulty of playing an instrument and minimising its downfalls can become a signature part

of its sound. An example of this is feedback from an electric guitar. It is, in theory, something to be minimised, but in many performances, it can be the focal point of a song or greatly enhance the audience's perception of a piece.

Another aspect of the instrument-as-device is that the history of an instrument can change how it is used. The interface that will be designed because of this research will be new to the performer. As a result of this unfamiliarity, a new way of using the interface may be found, so it is imperative that user testing is undertaken early so that this avenue can be explored if it enhances the usability and design of the interface. Users could also develop an extended technique, and these techniques could prove very useful for the interface.

Processes Rather Than Devices

A different way to look at the capability of an instrument is to look at the individual things it can do. The interface that will be fabricated is designed to manipulate audio effects, but a new technique could be developed during user testing. These features and different ways to utilise the interface could be added to the interface if they prove useful and enhance overall performance (Rodger, Stapleton and Walstijn).

Musician-as-User

This is the concept that a musician's skills and previous knowledge can change how they interact with an instrument. This is important as the familiarity of a musician with the interface can change how they use it. Their overall musical knowledge can also affect how they employ the interface. This means that it can be difficult to describe a typical user of an instrument:

> The same guitar will offer different potentialities for an accomplished flamenco player than for a child picking it up for the first time. Indeed, the functional properties of a given instrument can only be meaningfully understood relative to the effective capabilities of a specific musician at a specific period in her musical development and personal history. Thus, there may be no such person that can be picked out as the instruments' 'prototypical user'. (Rodger, Stapleton and Walstijn)

This means familiarity must be developed with the interface, and integration between the performer and the interface will be necessary.

Evaluation of User Devices

To assess the success of a musical device can be done in a few ways. One way is to see if it assists the user or is easier to use for the user compared to other devices. As the device that will be created is a device that is used to control audio effects using your hand, users may not have used a comparable device. Feedback will be taken during testing to see what aspects of the interface work and what can be improved. The goal of the interface will be to enhance live performance and make it easier for the user to manipulate effects.

Importance of Gestures in Live Performance

In work done by Torre, different types of gestures used by musicians are analysed, which will dictate the hand signals used by the interface.

"Gesture is human movement that carries some sort of meaning interpreted by a receiver" (Torre 13). A gesture can be physical, visual, or audio-based. Gestures can help an audience understand a live performance.

Regarding live music, gestures can be put into categories put forward by Torre (15). The first category is sound-producing gestures. These are actions such as hitting a drum or plucking a guitar string. As a result of these gestures, a sound is produced. The next category is communicative gestures. Communicative gestures are used to communicate between the performer and the audience or between performers. An example of this type of gesture is a jazz performer tapping their head with the palm of their hand. This refers to going to the top of a piece and is used so the other performers know what section to go to next. "Go to the top. Touching an open palm to the top of the head means, "Go to the top," which usually indicates going back to the verse, first stanza, or sometimes even introduction of the given tune. " (Wilktone). The third category of gestures is sound facilitating gestures. These are gestures that are used to aid in producing sounds; an example of this is a performer shaking their head in time with the music. The last type of gesture that is explored is sound

accompanying gestures which are gestures that are made in direct response to music. Examples are clapping hands or performers and the audience tapping their feet in time with the music.

As a result of this work, the finished interface will facilitate different types of gestures to achieve different things. One aspect of the interface is that it should engage the audience. Performances will have to be done with various gestures triggering different events to see if the audience picks up on them and if they could be used to enhance the connection between the audience and the performer. The interface will use sound-producing gestures. Different gestures will trigger user-defined sounds. This could be used to engage the audience. For example, an obvious gesture could trigger a sound, but testing must be done to see if this is evident to the audience. Sound-producing gestures will also be used as gestures will trigger effects. The user can move their hand in a pre-determined way to turn on or off effects such as a delay, reverb, or distortion. This will allow the performer to engage with the audience and trigger and manipulate effects in a more natural way.

Latency

Latency is an important factor to consider when designing a new musical interface. In work done by Lago and Kon, the concept of latency and jitter in musical performance is explored, and they say that jitter should be minimised.

When rhythm is taken into consideration, the threshold for perception is different. The concept of jitter is that a value fluctuates slightly on either side of the intended value. A jitter of 4 milliseconds on either side of a beat in strong rhythm-based music is perceivable to a human. It is not necessarily perceivable on a conscious level but is on the subconscious.

Instead, such high precision regarding rhythm means we can assess time intervals and attack times with around 4ms of precision in a subconscious level, and that discrepancies of this magnitude may affect the feel of some kinds of music (those that are based on a very steady isochronous pulse, like many forms of “pop” music). This makes a strong point for the case of try-ing to minimize jitter as much as possible in a computer music system if such kinds of music are to be supported. (Lago and Kon)

What this means for the interface is that for the audio processing, such as effects, jitter should be minimised as much as possible.

## Hardware

### Leap Motion Controller 2

*Figure 1 (Ultra Leap)*

The Leap Motion Controller 2 Figure 1 (Ultra Leap) is a hand-tracking camera that allows the user's hand to be tracked on the x, y, and z planes. It also has finger tracking and can detect different gestures of the hand. The Leap Motion Controller 2 was chosen for a few reasons; the first is that the manufacturer still supports it. Other options, such as the X-Box Kinect, are not supported by their manufacturer and are no longer up-to-date tech. The Leap Motion Controller 2 has excellent tracking capabilities and interfaces well with specific software to map hand gestures (Ultra Leap). The Leap Motion Controller 2 will be used to capture the values of the hand and allow them to be processed by a computer.

The other option to capture gestures was to fabricate a glove. The glove would have had different upsides and downsides compared to the Leap Motion Controller 2. The glove would have been based on the Arduino Nano; this would have been for a few reasons. Firstly, there is the cost; the Arduino is cheaper than a Leap Motion Controller. The Arduino's low cost means it is easily replicable and scalable if more gloves need to be made (Arduino). The second reason is the form factor; the interface between the sensors and the computer would

have been either located on the back of the hand in the glove or beside the computer. Both methods have upsides and downsides, but the interface attached to the glove makes the most sense as long cables will not have to be run for the sensors.

The glove would have had sensors integrated with it to capture gestures. The first sensor would have been bend sensors that would detect how much the user's fingers are bent; the bend of the user's fingers would have decided what effect is being manipulated. Multiple fingers will have bend control, so multiple bend sensors would have been used (Sparkfun). The second sensors that would have been used were an accelerometer and a gyroscope. These would have been used to detect the tilt of the hand and the speed at which the hand was moving. This would have been used to trigger and control different effects. A small screen would have been affixed to the back of the glove to show the user what effect would be triggered.

Line 6 Helix LT

The Line 6 Helix LT will be used to allow the bass's audio input to be sent to the laptop that houses the Pure Data patch. It will also send MIDI CC messages over USB to the laptop to allow the Line 6 Helix LT footswitches to control each effect's toggling. This is possible due to the Line 6 Helix Lt's MIDI command center, which allows MIDI CC messages to be programmed and sent through USB or a MIDI out on the back of the unit (Line 6).

Software

Pure Data

Pure Data will be used to parse the sensor data and transform it into the methods to control effects. Pure Data is a programming language that has the capability to manipulate audio (Puckette).

In this Pure Data patch, effects will be created, such as a delay, reverb, and chorus. The interface will manipulate these effects. A volume control feature will also be available in this Pure Data patch, which the interface will control.

MIDI

MIDI is a specification primarily used to control and connect electronic musical instruments. MIDI is a set of instructions that can be sent.

The MIDI command set describes a language that is designed specifically for conveying information about musical performances. It is not “music”, in that a set of MIDI commands is not the same as a recording, say, of a French horn playing a tune. However, those commands can describe the horn performance in such a way that a device receiving them—such as a synthesizer—can reconstruct the horn tune with perfect accuracy. (Lehrman)

Midi will be used to interface the Leap Motion Controller 2 with Pure Data (Puckette).

GECO

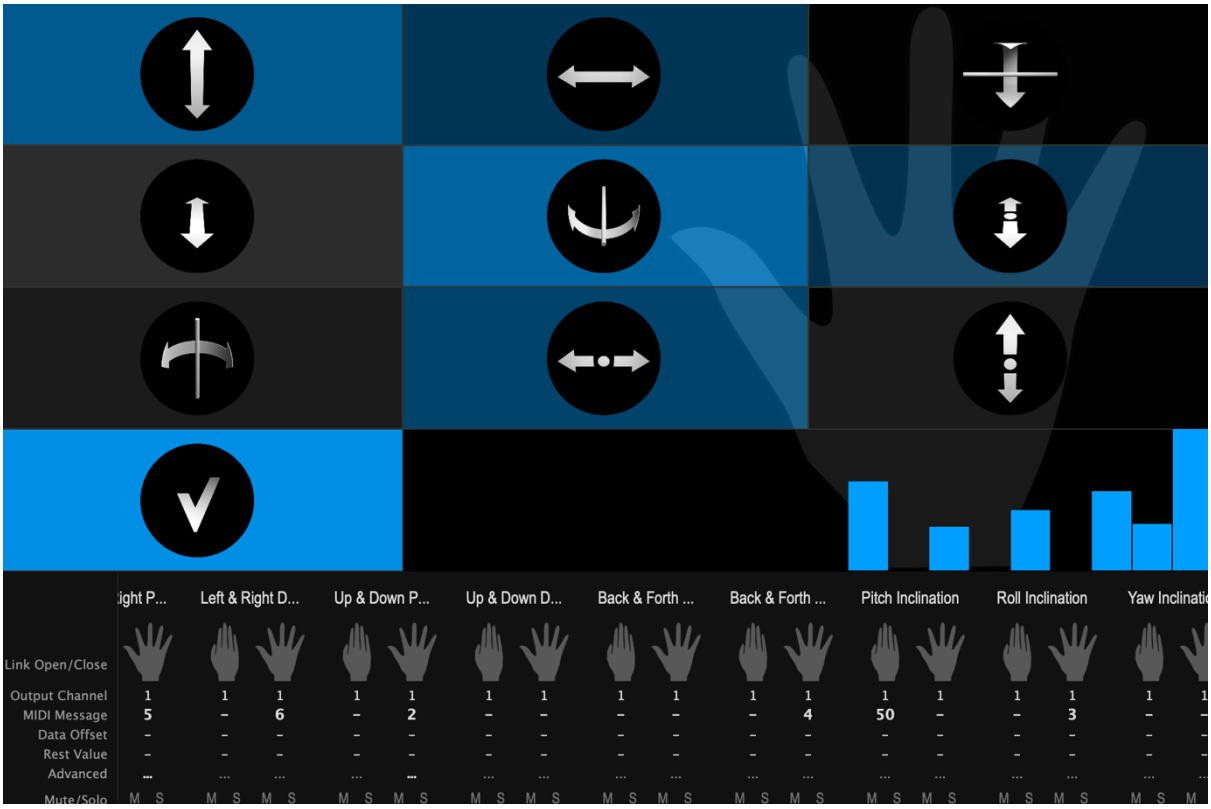


*Figure 2 GECO Software In Use*

GECO is the software that will be used to manipulate the Leap Motion Controller 2 data into MIDI messages. This will allow the Pure Data patch to utilise the MIDI messages from GECO. The GECO software facilitates gestural control such as height from the sensor, the tilt of the hand and the yaw of the hand, all of these gestures can be utilised with an open or closed hand Figure 2 GECO Software In Use. The GECO software allows the user to map what MIDI

value is used for each gesture (Uwyn LLC) , and this will allow many gestures to be utilised in the Pure Data patch.

## Conclusion

The previous work done in the area of designing new musical instruments and new interface devices will influence decisions made in the fabrication of the interface. Factors outlined in each section, such as latency, the intent of the instrument and gestures, will help decide the design intent and controls of the interface. The concept of musician-as-user highlights the importance of testing, which will be highlighted in the methodology below.

# Methodology

## Introduction

This methodology will explore how to answer the research question, “Can real-time gestural control of effects enhance a live performance?”. To test this hypothesis, an ambient bass performance was undertaken that utilised an interface created based on the findings of the literature review. Firstly, an interface was created to allow gestural control of bass effects, and a piece of music was composed using this interface. A performance was then undertaken utilising the interface, and feedback was obtained from viewers through a survey.

## Method One

A performance was undertaken to gauge the viewer’s response to gestural control of effects. An interface was fabricated to allow this gestural control, specifically tailored towards ambient bass playing and the performer. The first method used in developing this project was designing and programming the interface. The interface was designed to enable gestures to control effects. The interface was then used during a live performance to get data on its usage. The interface underwent many design iterations, and the principles put forward in the literature review above were utilised to create a cohesive and useful interface to enhance live performance.

The first method used in this project was the design and integration of the interface. The interface was designed to answer the research question, “Can gesture enhance live performance?” The following methodology outlines this process.

The interface is designed to facilitate audio effects control through hand gestures. Torre quantifies a gesture: "Gesture is human movement that carries some sort of meaning interpreted by a receiver” (Torre 13). The main gestures used by this interface are sound-generating. A sound is generated or created as a direct response to a gesture.

The hardware used in the interface was a Line 6 Helix LT to send the audio input of the bass to the computer. It also sent MIDI data from its footswitches to control the effect switching.

A Leap Motion Controller 2 was used to track the position of the user's hand. This position would then control audio effects.

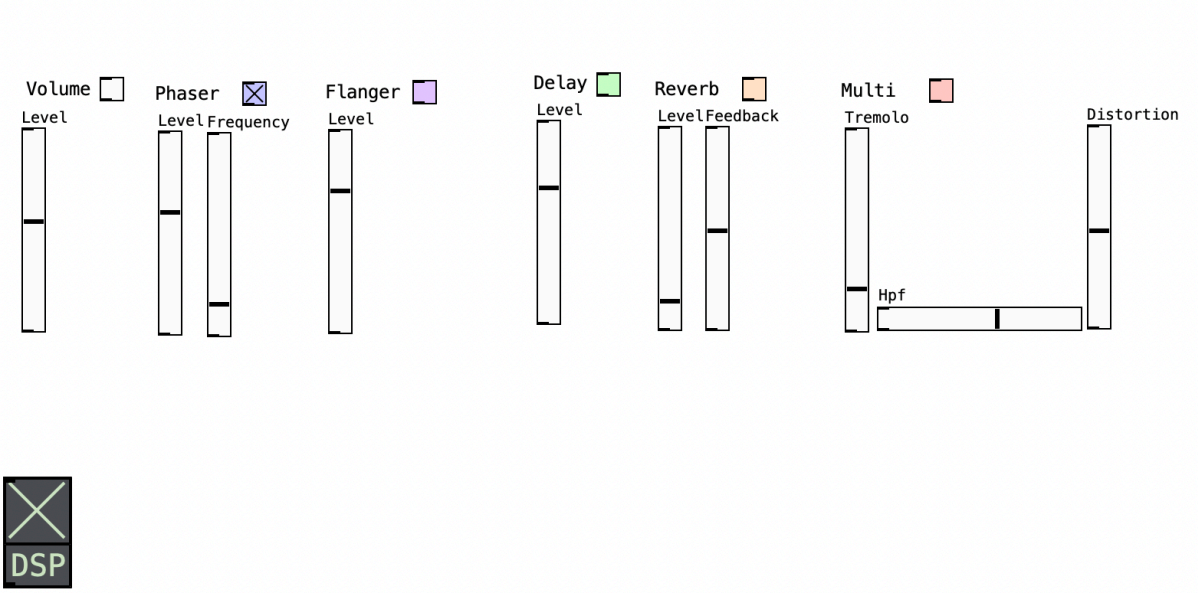


*Figure 3 Pure Data GUI During Use*

The Pure Data software was used to allow the control and provide the effects to the sound Figure 3 Pure Data GUI During Use. GECO was used to parse the Leap Motion Controller 2 data into MIDI data as the Leap Motion Controller 2 has no inherent way to track its values.

Iterative design was used throughout the development of the interface. As it was a self-performed performance, the music played during the performance and the interface itself developed alongside each other. When new technology was introduced, such as the Line 6 Helix LT to control effect switching, this capability had to be added to the patch and then fine-tuned to work with the performance.

Method Two

The second method used to answer the research question, "Can real-time gestural control of effects enhance a live performance?" was a survey. This was created to ascertain the opinion of an audience and confirm the findings in the literature review (Appendix A).

The survey used questions that were responded to on a scale of one to five and open-ended questions that respondents could answer in their own words. The survey gathered respondents' thoughts on gesture control, composition and overall performance.

Two identical performances took place to reach a larger audience. One occurred in the lecture hall of Sound Training Productions, and the other in a lab of Sound Training Productions. In both performances, the same piece of music was played using the same pieces of equipment. Viewers were not told anything about the performance before viewing it. They then viewed an ambient bass performance with the interface and a sole performer using it when playing bass. The performer then handed out paper surveys to the viewers and asked them to complete the survey. No further information was provided about the performance or interface. The survey was handed out straight after the performance. The surveys were then collected, and the performer could answer any questions the viewers wanted to ask.

To anonymise the survey, each viewer received a survey with a pre-written number. These numbers are not linked to the respondents in any way, and the surveys were shuffled before being analysed. The surveys were then digitised to aid in parsing the data.

One limitation of the survey was a sample size of 12. A second limitation may be a bias towards the performer. As all participants were peers of the performer for 4 years, they may have a bias depending on their feelings towards the performer.

Conclusion

The methodology outlined above highlights how gestural control has been integrated with ambient bass performance and the survey used to gather data on said performance. The feedback and data from the survey will be used to answer the research question, "Can real-time gestural control of effects enhance a live performance?"

# Analysis

## Introduction

This analysis will explore the design and implementation of the interface used for the performance. The composition will be discussed, and its interactions with the interface will be explored. Lastly, the survey design and results will be presented. All these aspects will help provide feedback and data to answer the research question, “Can real-time gestural control of effects enhance a live performance?”

## Implementation

### Hardware and Code

The finished interface for the project was successful. The project is based on a Pure Data patch and utilises a Leap Motion Controller 2, a Line 6 Helix LT and the GECO software to allow gestural control of effects.

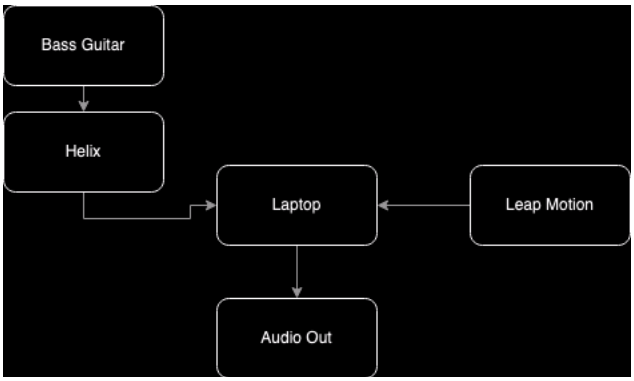


*Figure 4 Signal Flow*

The signal path of the interface can be seen in Figure 4 Signal Flow. The bass guitar is connected to a Line 6 Helix LT, which is then connected to the laptop, which hosts the Pure Data patch. No processing is being done on the Line 6 Helix LT. It sends the sound of the bass and MIDI messages from its footswitches over USB to the laptop. The Leap Motion Controller 2 is connected to the laptop via USB. On the laptop, the GECO software outputs MIDI values that are sent to Pure Data to control effects. The audio from the Pure Data patch is sent to the audio out. This can be any audio out that is connected to the laptop.

The Helix LT is used as an audio input, so the sound of the bass can be sent into Pure Data. It is also used to control what effect is being manipulated by the gesture. The footswitches on the Helix LT are programmed to send MIDI control messages over USB (Line 6), which Pure Data uses to toggle each effect control on and off. No sound processing is being done on the Helix LT. It is just being used as a MIDI controller and audio input. The footswitches are set to be latching; when they are pressed, they send whatever MIDI control value they are programmed to send and do not send a 0 until they are pressed again. A momentary style switching was also explored; this style of switching sends the MIDI control value when the switch is held down, then a 0 when the switch is released. The latching style control was chosen as it allows multiple effects to be controlled simultaneously, enhancing the interface's functionality during performance.


*Figure 5 Interface Ready For Use*

The Leap Motion Controller 2 was used to track the position of the user's hand. As the Leap Motion Controller 2 has no inherent way of outputting values, a software called GECO was used. Two changes were attempted with the Leap Motion Controller 2 to adapt it to the interface, but none of them were used for the final iteration. The first was to build an

enclosure to shield the Leap Motion Controller 2 from the user so it would stop tracking the hand position sooner. This would allow the user to be less strict with the shape of their hand as they are moving back to play their instrument. This ended up messing with the camera's tracking, and any issues with the shape of the user's hand were solved by practising with the interface and getting used to the Leap Motion Controller 2's field of view. The second change tried was to mount the Leap Motion Controller 2 to a bass guitar. This did not work; it also interfered with the camera's tracking. The angles did not work, and the user's arm would block the camera from tracking the hand correctly. The interface ready for use can be seen in Figure 5 Interface Ready For Use.

GECO was the software used to send the Leap Motion Controller 2 data into Pure Data. It parses what the camera sees and tracks the hand in an x, y and z plane. GECO has individual tracking for the left and right hand and can track many parameters, such as height, roll, yaw or horizontal distance. All of these could be tracked as open or closed hands. Only open-hand tracking of the right hand was used for the interface, allowing the user to close their hand and move it away if no tracking was desired. Alternatively, the user could move the hand drastically and then open it for a sudden large change in sound. The GECO software outputs values through OSC or MIDI. MIDI was chosen for its ease of use and practicality.

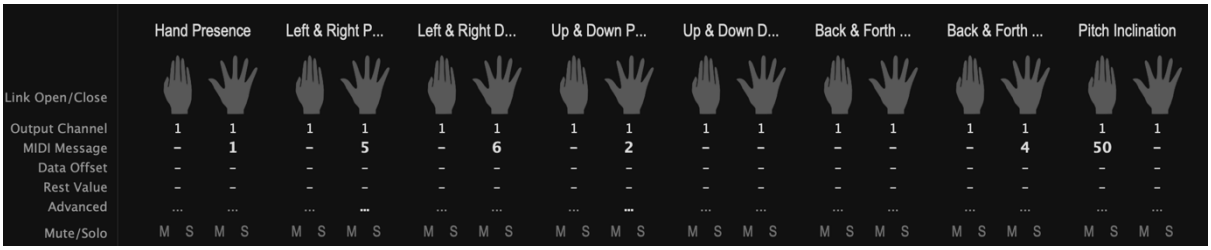


*Figure 6 GECO MIDI Numbers*

Each gesture could be assigned a MIDI message number (Uwyn LLC), and this allowed each MIDI message to be tailored to the project. If, for example, a gesture had to be changed from open hand to closed hand, the MIDI message could be removed from the open hand and added to the closed hand parameter Figure 6 GECO MIDI Numbers. This streamlined the prototyping phase and troubleshooting any problems that arose.

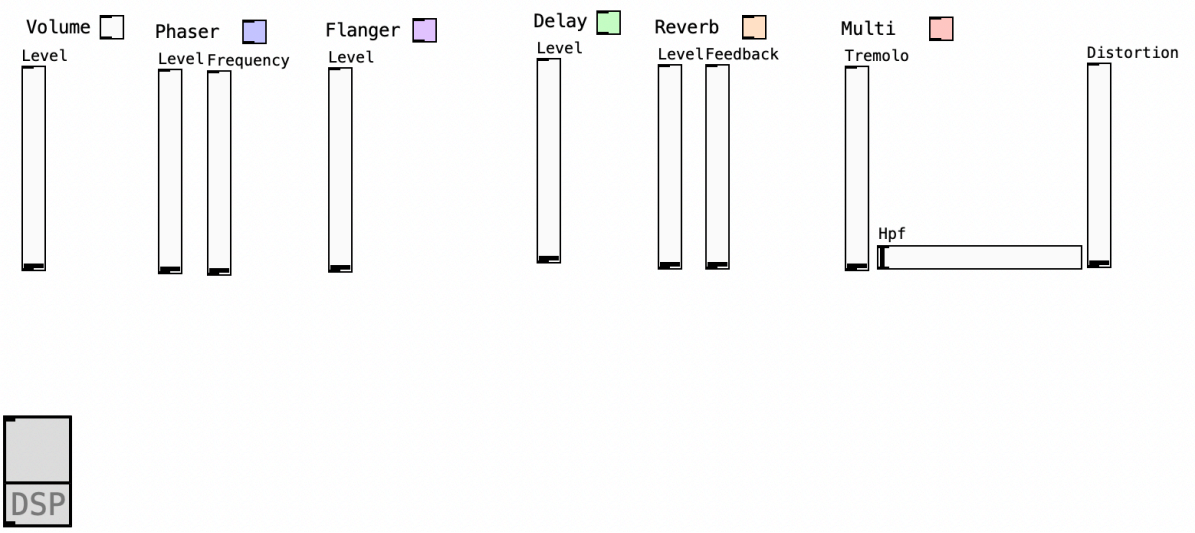


*Figure 7 Pure Data Patch GUI*

The Pure Data patch was set up using several subpatches to allow ease of use and so that the patch was not cluttered. A GUI was created as a visual reference of the controls that were being manipulated, which proved to be beneficial for performance Figure 7 Pure Data GUI. The GUI allows the user to see the change in each effect and what effect they are controlling. The patch was set up to receive audio from the Helix LT, MIDI data from the Helix LT and MIDI data from the GECO software through the IEC driver bus; it then outputs audio through whatever audio device is needed, for example, through headphones or an audio interface.

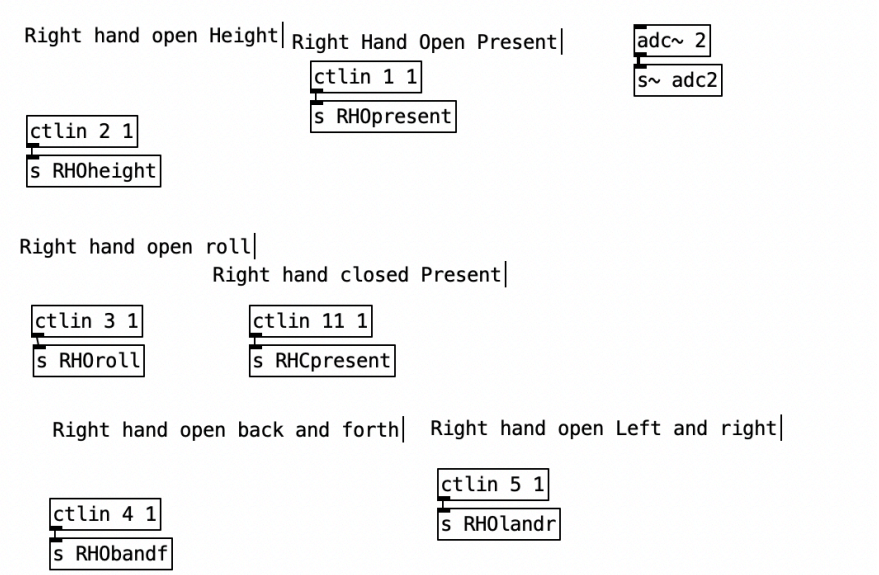


*Figure 8 Inputs Subpatch*

The MIDI inputs from the Leap Motion Controller 2 were set up as sends Figure 8 Inputs Subpatch. This allowed them to be called upon at any place throughout the patch by setting up a return. This allowed the MIDI value being received to be changed once instead of many times. For example, if the value of the height of the hand had to be changed from 0 to 127 to 0 to 120, it only had to be changed once before going into the send and not every time it is called on throughout the patch. This greatly simplified the parsing of the MIDI inputs and lowered the amount of clutter throughout the patch.

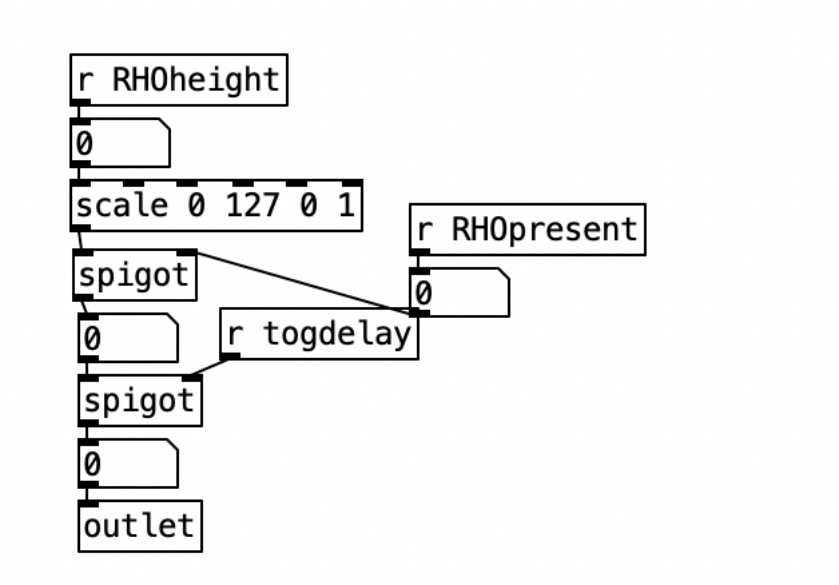


*Figure 9 Right Hand Height Subpatch*

One of the subpatches used throughout the patch can be seen in Figure 9 Right Hand Height Subpatch. The specific subpatch above is the value to track the right hand's height from the Leap Motion Controller 2 when it is open. This value will then be used to control the wet-dry of the delay effect. The MIDI value of the right-hand open height from GECO [r RHOheight] is scaled from 0 – 127 to 0 – 1 using the [scale] object. This allows the value to be better used to control the wet-dry of the delay. The [spigot] object only allows values if it receives a non 0 value in its right inlet. The value sent into the right inlet is [r RHOpresent]; this is the value of the right hand being open and tracked by the sensor. This technique allows the value to be saved after the spigot. If the spigot was not there once the user takes their hand away the value would return to 0. The second spigot receives [r togdelay] which is the value that shows if the footswitch corresponding with the delay effect is pressed. This spigot only allows the

value to change if the effect is chosen to be manipulated. The value is then sent out the outlet to the rest of the patch to be used.

The decision had to be made if every effect was unique or if they ran into one another. The decision was made that each effect should run into each other as this is a large aspect of the ambient bass performance. The downside to this was that the volume from each effect changed the volume of the next. A wet-dry blend subpatch called pd wet-dry, was created to allow the volume to be consistent. This allowed the wet and dry signals to be blended together. This allows a finer degree of control over the sound and means that the volume of each effect does not affect the next.

The effect switching is done differently from how most pedals switch. Normally, you press a switch on a pedal to turn the effect on or off. For the interface, you press a footswitch on the Line 6 Helix LT and change the parameters associated with that effect with the hand. When you press the button again, that effect stops tracking the hand, but the values selected remain. So if you have the wet-dry all the way to wet, then press the effect off, the effect stays 100% wet. This allows a finer degree of control for the effects.

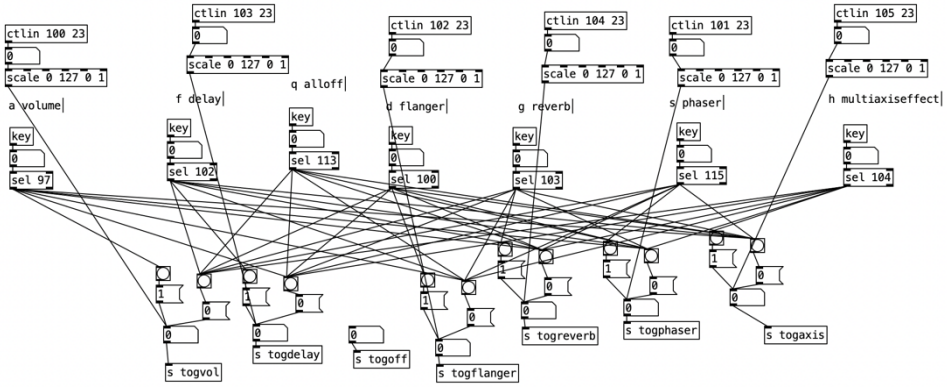


*Figure 10 Toggles Subpatch*

The toggles subpatch allows the effects to be manipulated by gestures Figure 10 Toggles Subpatch. This subpatch routes the control values from the Line 6 Helix LT to sends, which can be used throughout the patch. The Line 6 Helix LT control values are scaled down to 0 when the switch is turned off and 1 when the switch is turned on. This value is used to toggle each effects control on and off so that the hand can manipulate each effect.

In this subpatch, switching can also be used with a computer keyboard. This was set up early in the prototyping process before footswitches were used to control each effect's toggle. When the Line 6 Helix LT was used to toggle the effects, the computer keyboard control was kept as a redundancy in case anything happened to the Line 6 Helix LT during a performance. Switching with a computer keyboard differs from switching with the Line 6 Helix LT. When you press a key corresponding to an effect, that effect is the one controlled, and all the other effects are not controlled anymore. To deselect an effect, the q key is pressed. This was done as it is more functional than traditional switching when a computer keyboard is the interface used.

Effects

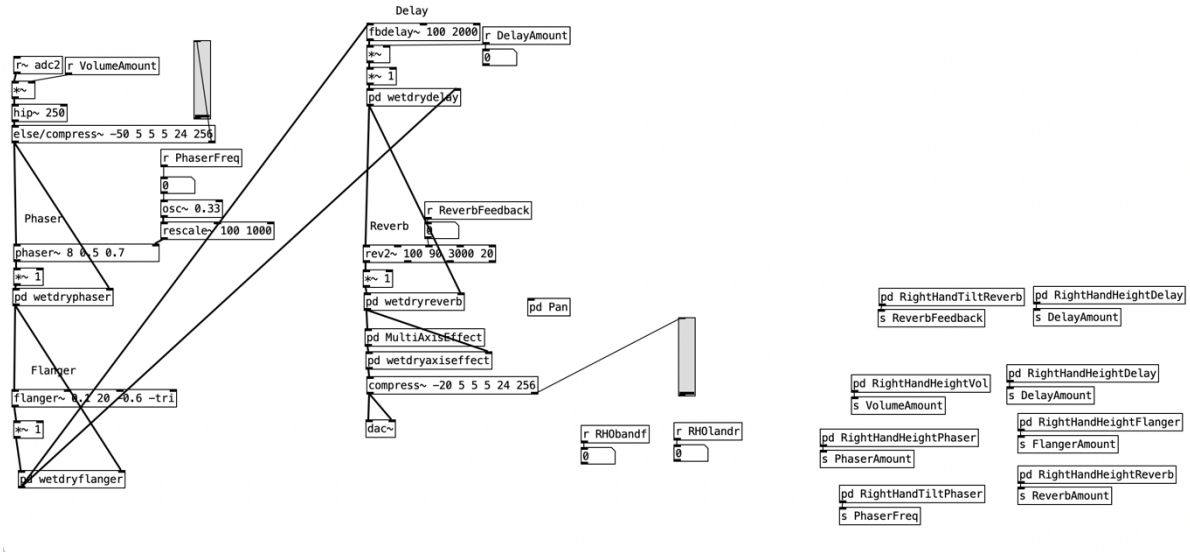


*Figure 11 Effects Subpatch*

The effects routing is as follows: volume -> high pass filter -> compressor -> phaser -> flanger -> delay -> reverb -> multi axis effect -> compressor.

All of the effects and related subpatches are contained in an overall effects subpatch, Figure 11 Effects Subpatch. The volume effect is controlled by the hand moving up and down. As the hand gets further away from the Leap Motion Controller 2 and is open the volume changes from 0 to 1. This is visualised in the GUI. This effect allows for volume swells, which are integral to ambient bass playing. It also allows the volume to be controlled and set to a specific point if desired. Utilising the hand for volume swells allows a far greater degree of expressiveness from the perspective of the performer over a tandard volume pedal. In the

same block of effects as the volume control, a high pass filter cuts out all values below 250hz as they muddy up the sound when it goes through effects, and these frequencies were not needed for the ambient piece performed. The sound then goes into a compressor to allow left-hand tapping to be used and to even out the attack of the notes.

The next effect is a phasor. This effect is used as it creates texture and depth in the piece and is a staple of the performer's sound. This effect has a wet-dry control and a frequency control that allows the frequency the phasor operates at to be changed by the tilt of an open hand. This allows greater control over the phasor's sound, and it can become more of a specific textural sound instead of an effect if the frequency is turned to its higher ranges.

A flanger is used to create movement in the sound. The interplay between the phasor and flanger was very interesting in creating texture and an evolving soundscape. The flanger has a wet-dry that is controlled with the height of the hand.

The next effect used is a delay. The delay has wet-dry control and is set to a fixed time as it works best with the ambient piece performed. The delay has many uses in the performer's sound, but they mainly use it to fill out space and create interest during tapping sections.

The reverb is the next effect used. As the delay is fed into the reverb, it creates a sound that the performer likens to the sound of a forest. The delay into reverb sounds like a sound bouncing off trees in the distance. The reverb has a wet-dry parameter and a feedback control. The feedback control changes the reverb time. The reverb maxes out just below an infinite reverb as the almost infinite reverb creates more texture by having a tail.

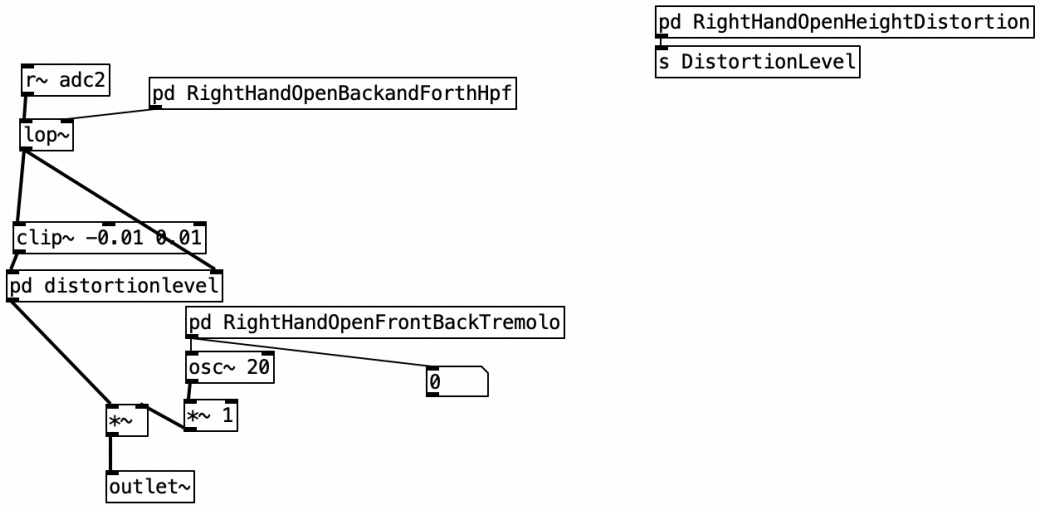


*Figure 12 Multi Axis Effect*

The last effect used is called the multi-axis effect. This effect is a subpatch that contains three effects used together Figure 12 Multi Axis Effect. This effect is separate from the other effects, and when it is toggled on, it produces the sound; when it is toggled off, the other effects produce the sound. This effect is called the multi-axis effect, as it is controlled by moving the hand on the x, y and z planes. Moving the hand left and right over the Leap Motion Controller 2 controls a high pass filter. A distortion mix is controlled by moving the hand up and down above the Leap Motion Controller 2, and a tremolo is controlled by moving the hand from front to back over the Leap Motion Controller 2. This effect was used to demonstrate the gestural control in a very easy-to-hear way and to allow a greater degree of interaction between the three effects.

These effects were chosen as the performer composed the piece with these effects in mind. The multi-axis effect was created to showcase gesture control. Through trial and error, the distortion, tremolo and high pass filter were settled on by the performer as they felt that they were the most expressive effects for themselves and that the effects enhanced the composition.

## Composition

The self-composed and performed composition used for the performance was composed in conjunction with the interface. The interface influenced compositional decisions, and aspects of the interface were changed based on compositional needs.

The piece of music performed was called "Signals." This name was chosen as it is a synonym of gesture. The composition is a solo ambient bass performance. The piece utilises different techniques to allow the performer the capability to use the interface at the same time. This allows the performer to manipulate audio effects live using gestures. The piece is based around a repeating motif. At the end of every phrase, there is a rest so the audience can focus on the changing audio effect.

At the start of the piece, the dry signal of the bass guitar is raised in volume with a gesture. A repeating motif is played. After every repetition of the phrase, a new effect is introduced in the following order: phaser, flanger, delay, then reverb. Throughout the first section, where these effects are added, volume swells are utilised with gesture control. The multi-axis effect is the last effect to be introduced, and it is utilised with left-hand tapping.

As the piece progresses, left and right-hand tapping is utilised. This technique allows the performer to manipulate the effect with their right hand when the left-hand tapping is used and to play a melody over a chord when both hands are used to tap, the right-hand taps a melody. The inclusion of the tapping technique required a compressor to be added to the interface as it would even out the volume of the tapped and plucked sections.

## Performance: Survey Results

As a result of this work, a performance using the interface was undertaken, and the viewers filled out surveys. Two performances took place and were identical regarding the piece performed and the performer. The rooms and viewers were different. Overall, there were 12 responses to the survey. Responses to each question were rated using a 1 – 5 scale, with 1 being the lowest rating and 5 being the highest. On the paper survey the respondents filled

out (Appendix A) 1 is labelled as lowest and 5 as highest. This scale is the same for every question except for question 7, where 1 is forced, and 5 is natural.

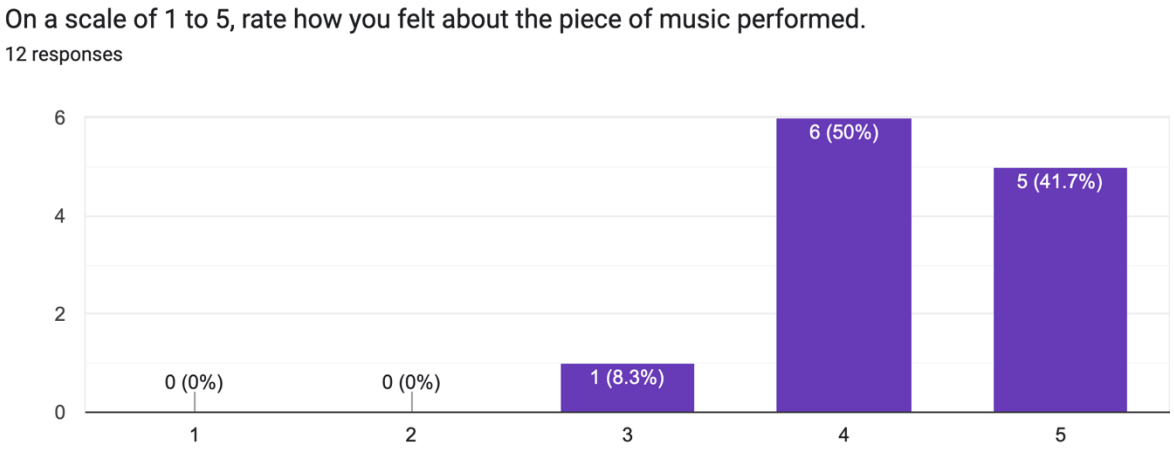


*Figure 13 Question 1 Responses*

Question 1 asked "On a scale of 1 to 5, rate how you felt about the piece of music performed." All 12 respondents answered this question, and as shown in Figure 13 Question 1 Responses, all respondents answered 3 or above.

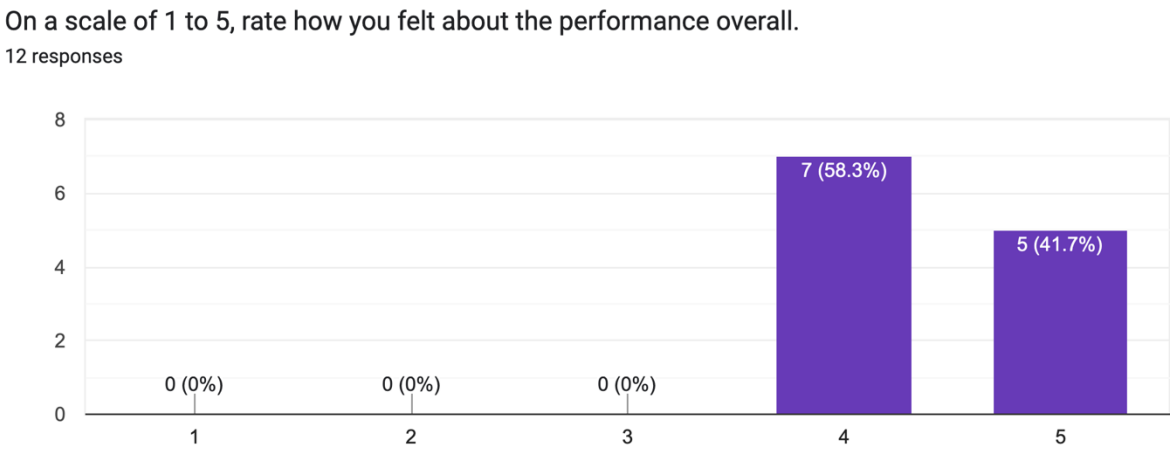


*Figure 14 Question 2 Responses*

Question 2 asked, “On a scale of 1 to 5, rate how you felt about the performance overall.” All 12 respondents answered this question, and all responses were 4 or above on a scale of 1 – 5 Figure 14 Question 2 Responses.

Question 3 asked, “Did the gesture-based manipulation impact your enjoyment of the music? If so how?” 9 of the 12 respondents answered this question. This question allowed respondents to fill in their own thoughts, which will be discussed in the discussion section below.

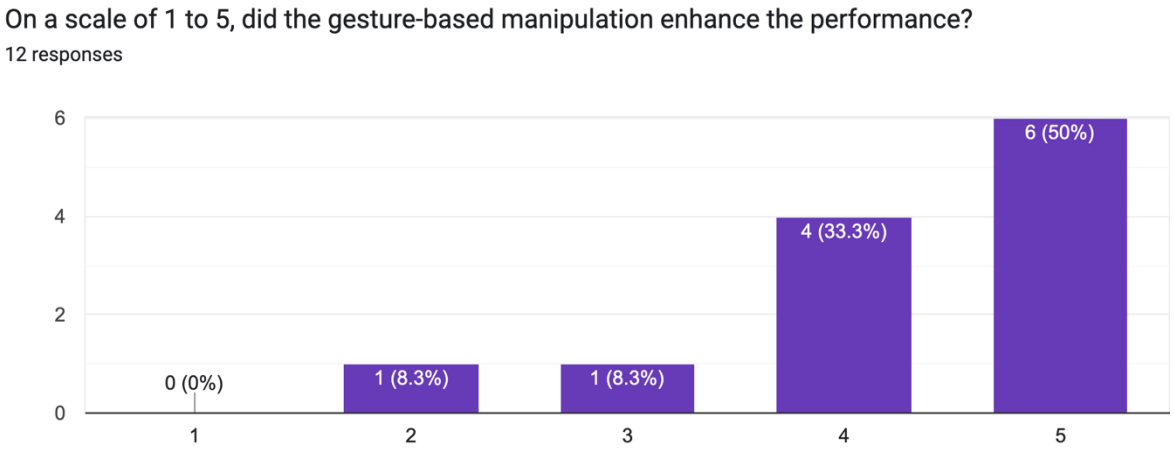


*Figure 15 Question 4 Responses*

Question 4 asked, “On a scale of 1 to 5, did the gesture-based manipulation enhance the performance?” All 12 of the respondents answered Figure 15 Question 4 Responses. This question had a range of responses from 2 – 5; the implications will be discussed in the discussion section.

Question 5 asked, “Did the gesture-based interaction add a new dimension to the performance? If so how?” All 12 respondents answered this question. This question allowed the respondents to write an answer, which will be explored in the discussion section.

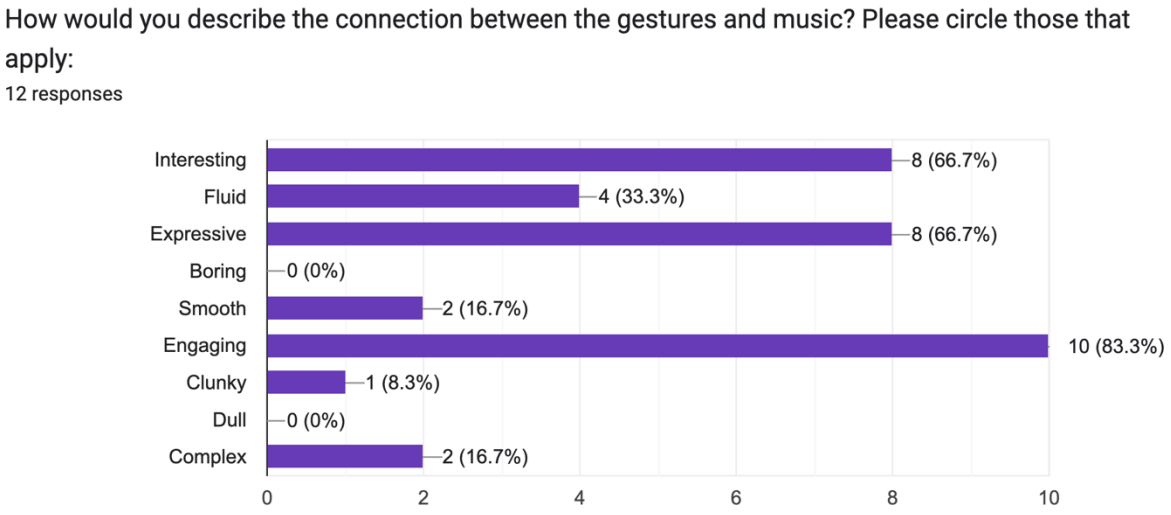


*Figure 16 Question 6 Responses*

Question 6 asked, "How would you describe the connection between the gestures and music? Please circle those that apply:" All respondents answered this question. The results of these responses can be seen in Figure 16 Question 6 Responses. There was also an "other" option where respondents could write their own words, which was left blank on every survey.

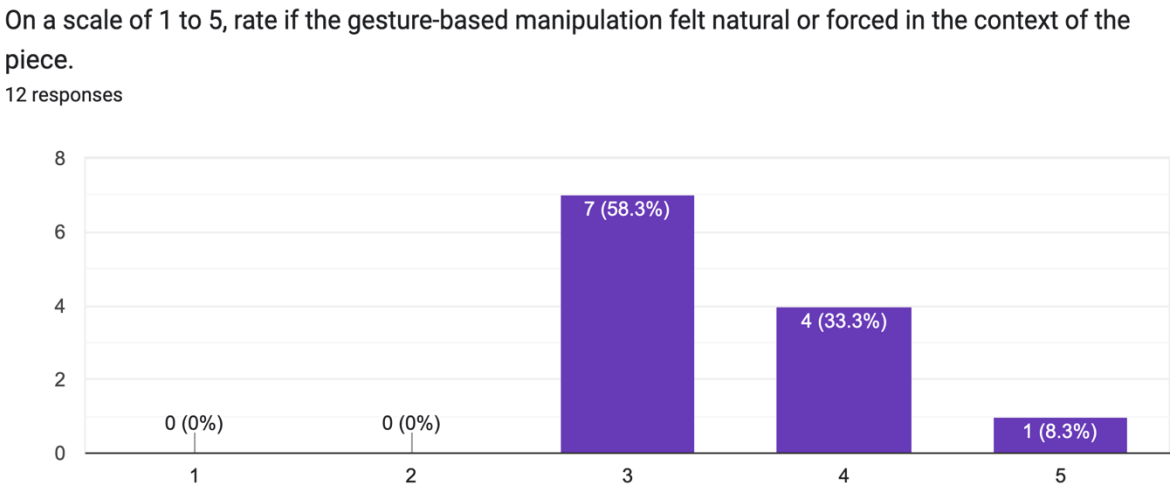


*Figure 17 Question 7 Responses*

Question 7 asked, “On a scale of 1 to 5, rate if the gesture-based manipulation felt natural or forced in the context of the piece.” All 12 respondents answered this question, and they all answered 3 or above Figure 17 Question 7 Responses.

The final question, question 8 asked, “Did the gesture-based interaction influence your response to the performance? If so how?” This was an open question, and respondents could write their own responses. All 12 respondents answered this question.

## Conclusion

All of the above results and work will be analysed in the discussion below. The survey will be the main data source used to answer the research question, “Can real-time gestural control of effects enhance a live performance?” The data collected could have implications for future work done in this field.

# Discussion

## Introduction

This discussion will explore the impact and results of gestures in a live performance. The interface, composition and survey results will be explored to answer the research question, "Can real-time gestural control of effects enhance a live performance?"

## Interface

The interface fulfilled its intended purpose, which is aiding in answering the research question, "Can real-time gestural control of effects enhance a live performance?" It was usable as a tool to provide gesture control for a live performance.

From the performer's perspective, the interface was successful. It allowed the performer to meld effects and playing in ways that they could not utilise before. The performer felt more engaged with the audience as the gesture control allowed them to manipulate effects without staring at a pedalboard. The performer felt that they had greater control over the effects, and they felt that this enhanced the performance from their perspective.

## Discussion of Survey Results

Viewers of a performance were asked to fill out the survey presented in the analysis section above. This survey provided feedback on the interface's gesture control and performance. One aspect of the performance that may have impacted the respondent's feelings towards it was that the footswitches on the Line 6 Helix LT were quite loud in the room as the ambient volume did not mask them. This was not marked down in any of the surveys but was talked about verbally later. If more performance testing is to be undertaken, steps must be taken to ensure the sound of the footswitches does not impede the performance.

The first question asked in the survey was "On a scale of 1 to 5, rate how you felt about the piece of music performed." The respondents were asked to gauge their feelings about the compositional aspect of the performance. This was done to see if there was a trend of people liking the piece but not the gestural control and vice–versa. six of the responses were a four, and five of the responses were a five on the 5-point scale. one response was a three, and no

responses were a one or a two. This shows that the overall feeling of the piece was positive. This could provide a bias where respondents' feelings about the music skew responses to the questions about gesture control.

The second question was, “On a scale of 1 to 5, rate how you felt about the performance overall.” This question was asked to gauge respondents' feelings towards the performance, visually, musically and sonically. Seven of the responses were a four and five of the responses were a five. The high ratings of the performance show that every viewer enjoyed the performance for one reason or another or a combination of these reasons, be it sonically, musically or visually. The positive responses to this question may prove that the answer to the question “Can real-time gestural control of effects enhance a live performance?” is yes. There is probable reason to assume that the gestures enhanced the performance. Evidence to further support this is answers to the third survey question, “Did the gesture-based manipulation impact your enjoyment of the music? If so, how?” as this was an open-ended question, there were various responses. Nine of the twelve participants answered this question. The response: “Yes. Adds a performative aspect, allows your eyes to follow both playing and gestures.” Shows that the listener feels that the gesture control added a performative feature to the performance. The addition of gesture control seems to add another layer to the performance for the viewer to follow. The addition of gesture control allows greater control over the audio effects. The following response shows that the listener is acutely aware of the gesture control and what it is controlling. This added interest could be what positively impacted their enjoyment of the music: “Definitely, the tremolo + volume control worked well. At one point the reverb tail was slowly brought down by hand and then the effect changed when the bass came back in.”

In question 4 the respondents were asked, “On a scale of 1 to 5, did the gesture-based manipulation enhance the performance?” The responses to this question were mixed. Six respondents put a five on the scale, four put down a four, one a three and one a two. These responses show that most of the viewers felt that the gesture-based manipulation enhanced the performance. The respondents were also asked, “Did the gesture-based interaction add a new dimension to the performance?” This question was an open-ended question where the respondents were free to write out their thoughts. All respondents answered this question.

Some of the responses further reinforce the speculation that gesture-based control added to the performance. Some of these responses are:

- Yes, added another layer of musical interest.
- Yes. The visual gestures drew my attention to certain changes in the music I may have missed otherwise.
- Usually with adding FX mid performance you're not able to see it, it was cool seeing it happen in front of you.
- Yes, allowed for the listener to feel more engaged with the piece as there was visual interest.

These answers show a positive response to the above question. The overall theme of the answers was that the gesture control added another layer of musical interest and that it was engaging. Some respondents said that it was interesting seeing the effects change in real-time with gesture control and that it added visual interest. These statements are further proof that gesture control enhanced live performance.

In question 7 the respondents were asked, "On a scale of 1 to 5, rate if the gesture-based manipulation felt natural or forced in the context of the piece." All twelve respondents answered this question. Seven said a three on the scale, four said a four and one said a five. The average of these numbers is 3.5. The majority of responses being a three, show that the audience feels that the gesture-based control was neutral in the context of the piece. It is neither natural or forced. Further analysis will have to be done with a different piece that utilises gesture control to see if the piece and gesture control can elicit a stronger response from the viewers.

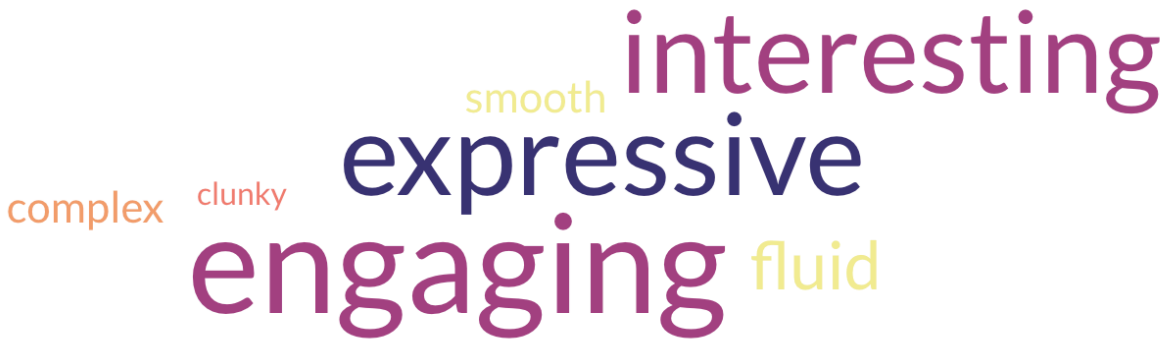


*Figure 18 Question 6 Word Cloud*

The respondents were also asked in question 6 to circle words that they felt described the connection between the gestures and the music, and this can be seen as a word cloud in Figure 18 Question 6 Word Cloud**.** The overall responses to this question were positive, and it can be deduced from this that gestures can enhance live performance. Only one response was negative, and this was the word “clunky” This could be due to the sound of the footswitches of the Line 6 Helix LT being heard during the performance. The main responses were as follows, “interesting” and “expressive” were circled eight times each and “engaging” was circled ten times. These words being selected so often show that the overall feeling of the gesture-based performance was positive, enhancing and creating interest in the live performance.

## Conclusion

Overall, based on the work done and data collected through a survey, the answer to the research question “Can real-time gestural control of effects enhance a live performance?” is yes. The data collected through the survey about the performance that utilised the interface was positive towards the gestures used in the performance.

## Conclusion

To answer the research question “Can real-time gestural control of effects enhance a live performance?” the following methodologies have been employed. A patch has been written in Pure Data that allows gestural control of audio effects. This patch interfaces with a Line 6 Helix LT and the Leap Motion Controller 2 to allow the user to manipulate audio effects with their hand. A piece of music was then written utilising this interface and was performed to twelve viewers. These viewers answered a survey to provide data to answer the research question, “Can real-time gestural control of effects enhance a live performance?” Based on the data collected, as it was mostly positive, it is reasonable to conclude that real time gestural control can enhance live performance, and in the case of the performance undertaken, they enhanced the performance for the viewers and performer.

There are several future developments to explore in this area. Firstly, user testing with the interface to get feedback and data from a range of performers on the usability and impact of the interface. Secondly, further live performances will be undertaken to obtain a wider range of feedback from a larger and more diverse sample group. Lastly conducting performances of identical pieces where the performer and piece are the same but one performance utilises the interface and the other utilises automated effects. This will provide data to compare and contrast audience feedback between gestural control of effects and a more traditional performance. The results of these three methods will influence the design and iterations of the interface going forward.

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# Appendix A - Survey

**Survey Number:**

1. On a scale of 1 to 5, rate how you felt about the piece of music performed.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Lowest | | | | Highest |

2. On a scale of 1 to 5, rate how you felt about the performance overall.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Lowest | | | | Highest |

3. Did the gesture-based manipulation impact your enjoyment of the music?
    a. If so how?

4. On a scale of 1 to 5, did the gesture-based manipulation enhance the performance?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Lowest | | | | Highest |

5. Did the gesture-based interaction add a new dimension to the performance?
    a. If so how?

6. How would you describe the connection between the gestures and music?
   Please circle those that apply:
    a. Interesting
    b. Fluid
    c. Expressive
    d. Boring
    e. Smooth
    f. Engaging
    g. Clunky
    h. Dull
    i. Complex
    j. Other:

7. On a scale of 1 to 5, rate if the gesture-based manipulation felt natural or forced in the context of the piece.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Forced | | | | Natural |

8. Did the gesture-based interaction influence your response to the performance?
    a. If so how?

Thank you for participating.