5.2. The Cyber-guitar system: nuance in instrumental practice as a motivation for immediacy within gestural controllers

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Abstract

This article examines the Cyber-guitar system developed as part of a doctoral research project. The specific focus lies on the use of various body-attached controllers (gestural or prosthetic) and the relationships between these and the particular nuanced and sonic changes that are facilitated. The system is located in a continuing organological and instrumental developmental process. It has been intrinsic to the instrument since its inception rather than being a wholesale departure or new, independent appendix to it. The development of the system is ongoing and continues to technologically enable the instrument. The intent is to further realise extended and specifically fine nuanced changes to an increasing variety of effect parameters. At the core the system ensures that these changes are available to the performer with no lag. Changes are as immediate as the tactile-acoustic experience of plucking a string would be. The performance, composition, technology and organology are neither researched nor considered as independent entities, rather the research process has involved interrogating these through regular performance events of a varying and comprehensive nature. These events have intentionally avoided using pre-recorded material or samples modified live via the suit engagement. One of the goals of the project (as located within instrumental tradition) has been to integrate the new design components into the performer's practice of composition, performance and improvisation. The instrument's development has, thus, involved parallel areas of interrogation. With each imagined nuance the process of development has had multiple stages. These broad stages can be chronologically understood as: (1) desired signal modification, (2) technological realisation, (3) performer experimentation, (4) compositional and improvisational application, and (5) application in real life performance. As a specific process and its audio result are successfully achieved the new skill is absorbed holistically into the performer's repertoire of techniques and musical expression.

Keywords: gestural control, nuance, cyber-guitar, augmented instrument, continuous controllers, organology, improvisation, notation

Introduction

Instruments (in the acoustic sense) have a long and detailed historical development. Their organology runs parallel to the development of the technical skills required to compose for them and to play them. This is a natural evolution, one in which the composers and performers imagine new sounds that often propel revision and additional instrumental design. The new instrumental and compositional/performance developments lead to new technical requirements that quickly develop into fine motor techniques. These are then subsumed into instrumental practice and become part of the ongoing skill narrative. Such techniques often required small, nuanced movements that are not necessarily observable to the eye of the audience member. In my own observation it is often a point of pride or musical authority in listening culture when these nuances and fine motor movements or gestures are observable, and their musical results heard.

In the history of the guitar the design process changed during the twentieth century due to the rise of the electric guitar. Initially the guitar's electrification was principally propelled by the need to raise the volume of the instrument within a big band setting. However, the nature of the amplifier itself and the later creation of guitar effects pedals spawned a new organological system. This system was one where signal modification could take place outside the instrument on the signal's journey to the amplifier, but most importantly away from the practitioner's body. Guitarists and other musicians have expressed an insatiable desire for ever more varied signal changes and this has led to a dizzying variety of processors, and on each of these an ever increasing variety of complimentary control possibilities. Naturally, musicians have desired to access these specific changes with increasing frequency and simple on or off values are no longer an acceptable maximum.

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Gestural or extended body control opens up these additional possibilities to the guitarist (and, indeed, any other instrumentalist or vocalist) leaving the entire body available to the performer as a potential actuator. No longer are the hands, feet or voice the singular ways of generating control changes. These options are being explored at phenomenal rates. The current project sets out to specifically examine gestural modification in a way that furthers existing guitar performance methods rather than abandoning the instrumental technique (or parts thereof) or replacing integral components of the instrument. The guitar itself is of no intrinsic value other than being the researcher's lifelong instrument and the discoveries and technologies developed could quite easily be deployed by any other instrumentalist or vocalist with specific integration with that instrument's technique. The controllers in general have intentionally been imagined in such a way and the controller suit would only be physically prohibitive for a small number of commonplace instruments.

The types of movements selected for refinement in the controller have been calibrated in a way that relates directly to nuanced motions. These minimal movements have been calibrated based on integration with the existing performance methods. In other words, the hands and arms of the performer can continue playing the instrument whilst making a control adjustment. For more visual or easily observable events movements have also been assigned to aspects of the controller suit. These movements can be made without the hands being placed on the instrument or with the hands held outside of the conventional playing position. The immediacy of the system allows for extremely fine movements to be made with accurate control response due to the continuous controllers potentiometers having roughly 4,000 points per cycle of rotation. Thus, they demand nuanced technical skills, not unlike those one would learn as part of a traditional instrumental skill base. The project did not aspire to large visual effects that could easily be identified by audience members and associated with audio results, but has rather focussed on the types of fine motor movements common to skilled instrumentalists where the goal is nuance with maximum sonic change.

Background

This article focuses on the exoskeleton component of the project (specifically the nuanced or minimal movements that are principally activated by the suit). The progress of this component took place as part of a number of developmental layers. The design of the instrument was first laid out as part of a range of musical goals. These included:

- Bringing selected controls into the instrument itself within the immediate reach of the performer's hands.
- Creating a three-way signal path inside the guitar to provide capacity for the spatial manipulation of sound. This allows the user to switch between different signals inside the guitar.
- Ensuring that this signal path should output to looping (live audio recording) devices for the recording of minimalist (phase drift) compositional materials.
- [Start with a verb] The ability to modify signals both once they have been looped and to modify them in combination with the improvised signals on top of them.
- [Start with a verb] The ability to further record the modified looped signals and new layers for additional base sound layers materials (bed layer material) at the end of the entire signal path.
- Creating a system that was not computer-dependant, in the sense of being a system that required a laptop or desktop computer for the navigation of the controller changes.
- Ensuring that the final result was one that could be imagined and used in the way a standard instrument is, and is a stand-alone instrument system that could be performed on with the degree of mastery and complexity common to existing instruments.

In light of these goals this system exhibits a slightly different nature compared to many other gestural or physical controllers. Mainsbridge and Beilharz (2014, p. 110) assert that, "for musicians hoping to incorporate gestural control seamlessly into their performance practice, a balance of technical mastery and kinaesthetic awareness is needed to adapt existing approaches to their own purposes". This kinaesthetic awareness and technical mastery go hand-in-hand as an evolutionary pair that converge to create specific techniques. This is the case for a system that is resident in a holistic single performer, however, the pair is often divided in discourse. This may be due to a larger portion of gesturally enabled performances being presented with two or more performers, where the

instrumental performance and gestural activation are split. The current system depends on both being continually present for its ongoing evolution.

The Cyber-guitar seeks to amalgamate kinaesthetic awareness of any additional controllers into the instrument so that holistic integration of the control variates replicates a learning process similar to the initial procedure of learning an instrument. Schacher (2013, p. 1) explains that instrumental training

> in its initial stages at least, is mainly concerned with building this rapport between the body and the actions on the instrument that produce the sound. It serves to imprint the shape and sound of an instrument and its affordances and constraints into an adaptive, dynamic, extended and perceptual body.

The current project has sought, over its three to four year development, to mimic this process. In order to do so, original compositions were composed, practised and performed at each major design juncture allowing the user to absorb the techniques and to refine them. The performances and compositions were specifically designed to focus on these aspects and then, after the concert performances, additions or removals could be made.

This intent has led to an ebb and flow between the processes of improvisation, composition, performance and organology. These traditionally well-delineated areas have blurred in unexpected and informative ways. Ingrained procedures of taking the static instrument as inspiration for the composer's writing, then intended for a performance, have been catapulted into flux. If the instrument is not complete then the relationship no longer holds linearity. Cadoz (1988) refers to this scenario in the following way:

> if his (the composer) idea, his idea of the object to be produced is perfectly preconceived, with a given system, he will look for the command that will achieve it, will have to reconsider the device itself if necessary, and go back and further between the device and its use. - but inversely, the device, if used in an exploratory fashion may propose objects, although not preconceived by the creator, that he may wish to use in his language. (p. 3)

Cadoz's (1988) concepts of material are useful when understanding the motivations for continual ebb and flow within the system. The notion of material breaks down the idea of composer (or improviser) in a way that leads away from the division between the two and brings a focus towards the instrument (in the holistic sense) as a method for the generation of useful material. His assertion that the "rules of harmony and counterpoint are organisation producer systems" (1988, 3) could be brought to bear on any particular formality of logic, even ones as yet undiscovered. These systems in essence become producer systems in their own right facilitating new capacities and new avenues of discovery. They are new producers of material. Cadoz (1998) continues by explaining the following:

> In fact the composer can formalise a number of rules or laws of organisation and materialise them by modelling in an algorithmic system. His relationship becomes to some extent to that of the instrumentalist with his instrument. As soon as he explores the 'behaviour' of the system and chooses a given organisation at a given moment by prescribing a specific "command", he removes the initial indeterminations proper to the system. The compositional model becomes, in his turn, production system and sets up a new dialogue and experimentation order between between creator and tool. This objectivisation of the compositional model into an automatic system is virgin territory, made accessible by the computer. (p. 4)

Description and build of the system

As much as the process of building the system may seem descriptively linear (or retrospectively is describable as such) the initial designs were embarked upon with a Reed Ghazala (2005) inspired hardware hacking aesthetic. This stance provided some necessary impetus at the outset and also created an imagined space where the absence of a computer seemed plausible. Lähdeija, Wanderely and Malloch's (2009) work on ancillary gestures for effects tracking in the electric guitar is an example of one of many existing software-driven solutions (principally Max MSP) that solve many core issues of the project. However, I set out to drive the research using familiar effects pedals and wished to enable their access for the guitarist as I contend that the tactile familiarity of this system may be key to realising ongoing usage beyond the project scope.

This was not, as one may easily assume, due to simply owning the units, but rather to the tactile familiarity that can be built up with these units. This offers a certain physical familiarity that many guitarists find comforting and brings the project into the realm of plausible usability. Instrumentalists build relationships with certain pieces of electronic equipment and these relationships are analogous to those held with traditional instruments. Even Brian

Eno desires unpredictability in the Yamah DX7 for instance and 'is famous for his mastery of' it. (http://www.soundonsound.com/sos/oct05/articles/brianeno.htm) and the inspiration this creates. Often the experience of working with software-based effects processes or plug-ins lacks this viscerality.

An entry level hollow body jazz arch top was selected for the instrument due to the internal cavity and a hole was cut out of the back to house circuits. Circuits were selected based on the signal path model seen below and the best case scenario was a combination of 'size meets audio'. The brands and models were chosen based on characteristics that are unique in how they distinctly colour the sound and their behaviour during controller changes. These aspects were chosen to ensure a sonic difference in the three outputs (see figure 1). Also, the choices were made pragmatically in relation to the units being able to fit into the cavity and also in terms of ensuring that the potentiometers could emerge out of the surface side of the instrument.

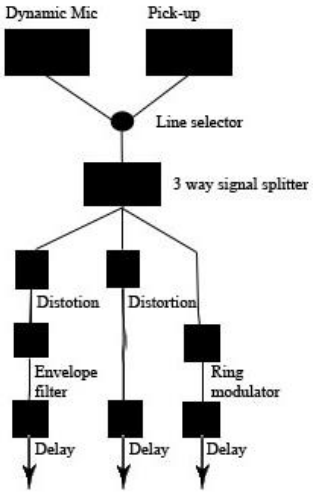

Figure 1 - Original signal path

A similar process of experimentation and adjustment threaded through the balance of the project. The second component to be built was an attempt to connect three looping devices through a single switching mechanism to explore the possibility of phase drift across time. This was not successful. The ganged switch created chip noise interference and, even when the units where triggered together, the amount of time that had to elapse before any noticeable drift (phase in the loops) was observed made the system practically unusable.

At other stages ribbon controllers were attached to various points on the guitar and then used in live performances. However, these proved to be musically ineffective, as were infra-red controls and web-cams. The original dynamic microphone installed in the instrument has also been abandoned in favour of an iPod headphone which I have now inserted into the mouth.

The consistent drive behind the construction has been musical usability above all other aesthetic goals. This has been assessed throughout the three to four year process and within the numerous performances in which the system has been used. Each performance included substantial modifications as well as minor tweaks and the system has, thus, grown organically in relationship to performance practice.

The system currently in use has the original enabled guitar (hollow body electric with effects built in) which then directs the signal to three unlinked looping devices. These are then individually sent through a pitch shifter, bit crusher and a multi effects unit which are each switched on or off with the feet.

The exoskeleton was the final component of the system to be realised.

This section of the system uses a re-purposed midi controller suit mapped through an Arduino. The suit is attached to the upper torso of the performer and behind the arms. It provides multiple continuous controllers on certain joints. Although all of the controllers are not yet in use they include two values on the shoulders, two on the elbows and four on the wrists. The ones currently used most are the wrist controllers, however, as comfort with the system is growing the desire for additional joint and range of usage is increasing. The range of motion on the suit has been calibrated in two ways, firstly based on the range of motion available with no impact on instrumental

performance and, secondly, based on range of motion when hands are off the instrument. This easily separates the available joints as, for instance, certain movements on the shoulders are not practically useful whilst playing. Once the performable ranges of motion have been established they are then mapped in software to midi 0-127 values and uploaded and saved onto the midi-enabled Arduino.

In each of the floor-based effects units one or more values are controllable via the exoskeleton. For instance, the pitch shifter has a two octave pitch range assigned to the right wrist of the performer and is post one looping device. The performer can, thus, activate a pitch incline on one of the three signal paths exiting the guitar whilst playing or, if this internal signal path is disengaged, then the shift would apply to only a recorded loop if present. This particular joint choice means that the right hand of the guitarist can continue plucking the strings, uninterrupted, whilst changing the pitch of the signal.

The bit crusher device is assigned to two of the signal paths exiting the guitar, post two looping devices, and is in a dual mono state of configuration. The clock speed of the digital to analogue converter in this device is assigned to the left wrist. This means that by pushing the neck forwards and backwards the clock speed can be adjusted with no playing interruption. The clock frequency for the converter is assigned to left elbow height and, again, can be adjusted with no playing interruption.

On the multi effects unit up to four individual effects can be engaged at any given point during performance and many of the individual parameters can be assigned to any particular joint on the suit. The currently used choices of assignment have been selected through many hours of improvisation and experimentation and their ranges of expression have also been selected based on performance experiences. For example, in the multi effects these controllers range from delay times, to reverb duration, mono synthesizer pitches, auto panning movements and many more, however, their use is still being adjusted and interrogated through performance.

Due to the three-way output of the instrument the majority of the concerts have been presented in a manner that includes spacial experiences for the audience. The least complex scenario has been that one guitar is panned to the left, and the other to the right and a further one in the centre to provide signal distinction. With duration values (such as on delays and reverb) being adjusted by the performer on the left and right images the spatial experience becomes amplified. The most successful concerts have been presented in surround sound with the three signalspanned into the corners of the room. The spatial movement, therefore, becomes three dimensional. This allows an individual performer to improvise with the three dimensional space and to tailor signal movement in this way.

A WiFi or Bluetooth enabling of the exoskeleton is currently in design. Fader volume adjustments will, thus, become improvisational thereby heightening the three dimensional capacity of the system as well as freeing the exoskeleton from cabling which has proved cumbersome.

Performance and composition: motivational directives within the project development

Performance and composition are research-driven initiatives within the scope of the Cyber-guitar project. From the outset the expectation was that, by placing the performer and system regularly into a public forum, the project would benefit as the stresses inherent could not be duplicated in laboratory settings. Further, these environments were continually conceptualised to interrogate specific goals that were felt to be integral to the hope of a long-lasting and usable outcome for the research. Some of these goals included:

- Working with other performers across a wide range of instruments, genres and stylistic influences.
- The behaviour of the various system aspects should be interrogated under varying notational and structural systems.
- Considering notational materials that include original composed materials as well as materials from multiple other styles and periods.
- Exploring performance situations of both a professional and public nature to place stress on the user and systems. Ideally, touring with the system should be a goal.
- Stretching the technologies to their limits and introducing new aspects in as many performances as possible.
- Recording the performances, where possible.

- Reflecting upon all performances, artistically and technologically, and these reflections should inform system changes and adjustments. Feedback should be sought from collaborating musicians, engineers and audience members.

Descriptions of five concert examples are provided below.

What if the machines spoke back to you? - August 2010

This concert used the system in collaboration with two other musicians (Jacob Israel on electronics and Justin Badenhorst on drums) and endeavoured to improvise through a logic (computer daw) audio mixing system. This system was specifically designed to feed audio to the performers after having been directed through audio effects where the parameters were configured to behave in selected random ways. Conceptually the concert intended to present wholly improvised music for a limited 45 minute set, interfacing the live performers through an unpredictable mix platform. Although the process of setting up the interfaces took seven hours the concert was not rehearsed in any way beforehand (other than procedural and process agreements being made) and the set-up process consisted only of signal and process testing. The score provided for this event was a single hand-drawn line of stepped heights on a sheet of paper. This was the first graphic score material used.

What was observed was that it became unclear in large sections of the event as to who or what was generating the signals, and who or what one felt one was responding to. This was due to the guitar system as well as the software system being new sonic entities in the hands of all performers. It was as if the performers' own signals became unrecognisable to themselves through machine intervention. This unpredictability in sonic result has since been an enticing goal and the project has, at least in part, continued to aspire to it. This concert provided evidence that inside the project unpredictability creates sonic contingencies that propel the creativity of the event to unexpected elevations. In essence the newness of the material generated by system extension fused with unpredictability yields creative contingencies beyond the performers' imaginations.

What if the machines took control? – August 2011

The instruction for this event was that the performers now had to wait indefinitely for the system/s to provide audio feedback and, thus, the systems became an additional performer. The concert was designed to be an extension of the research goal from the previous one in August 2010. It was simply built around the naïve idea that if the random machine interventions elevated the artistic output surely handing over the initial creative impulses to such events would energise this process further. Fuelled by the encouraging results of the previous event two additional performers were added and the size and scope of the software interface were expanded. Unlike the previous concert no score material was provided and only waiting was specified.

The concert began in absolute silence with the performers instructed to wait for the mixing interface to generate sound from the silence and only then to begin engaging or interfacing with it. At a point the newer members of the ensemble could no longer wait for the physically absent audio and the concert became a live improvised event as they began playing. This insecurity derailed the concert from an aesthetic standpoint, however, the audience members were (on the whole) unaware of this and enjoyed the event. Retrospectively one could say that the absence of presence made for an absence of gesture and this created an unbearable tension for the newer performers. From the research standpoint this highlights the relationship between the system development and the participants. Although the goal of waiting was not realised at this particular performance components of this intention remain a part of the project.

The link between this concert and the previous one was vital from a system based organological standpoint and herein lay the aesthetic failure. Further, from this point onwards score materials have been used for each concert.

Zoo Lake Bowling Club and Bassline club – 2011-2013

As part of the Carlo Mombelli trio I used the system almost weekly in a modern jazz trio context. This allowed for extremely regular testing of the system. Without this regularity the system stability and familiarity with it would not have been possible. The relaxed nature of the weekly club date, along with the fact that many compositions were repeated weekly, resulted in a great deal of trial and error being possible. Mombelli's music is, in most cases, composed material with modern jazz styled improvisational sections and some use of free improvisation. His music uses conventional score practices with word-based instructions at various points.

Czech Republic tour – November 2013

This tour booked 13 performances in as many cities in the Czech Republic and Slovakia in 14 days. This tour was vital for preparation for a major performance planned for February of the following year. The tour placed pressure on the system and performers due to the expansive repertoire performed along with the physical testing of the system.

The concerts up to this point had explored a wide variety of compositional materials ranging from traditionally scored classical compositions by composers such as John Cage and Mortin Feldman to graphic notation works by the same composers as well as by Cornelius Cardew. Original graphic and standard scored original works were explored and jazz standards were also used on tour. During the Czech tour popular works were also used for the first time, specifically works in the No Wave and Grunge styles due to a historical link between Cardew and Sonic Youth.

Doctoral recital examination – February 2014

The intention for the recital in February 2014 was to present a completely new composition for the performance, one which would synthesize the research thus far and bring the best elements to bear on a new work.

The examination presentation was a larger scale performance booked in Johannesburg in February 2014. As many of the lessons learned from the previous performances influenced the specifics of the concert. A composition was created for the concert (see figure 2) incorporating the most effective elements used thus far. These included pointillism, graphic designs and conventional harmony all deployed across a clocked timeline (see figure 3).

A quadrophonic PA system was used to maximise the spatial possibilities that the three signal paths provided.

Signal path interventions to the monitoring feeds were pursued, but were aligned to the digital clock rather than introduced randomly.

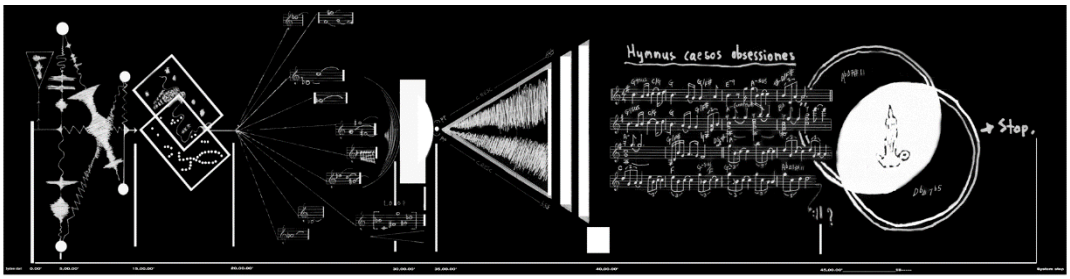

Figure 2 – Full graphic score

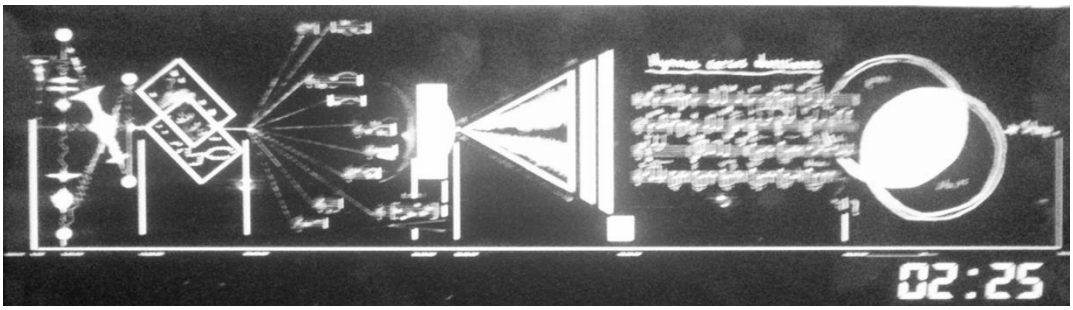

Figure 3 – Digitak version of graphic score including digital clock

This performance offered useful insights:

1. The composition provided a timeline and was experientially successful, however, many audience members expressed the desire to hear the system deployed on known materials
2. Whilst the audio events or effects were easily heard from a standpoint of sound, the fine movements made them hard to recognise visually.

The concerts since this time have used more familiar popular materials to address point one, however, point two has been identified as one which this project will not completely adjust to. Rather, it is the confirmed position of this project that, like the fine nuances of an acoustic instrument, it it not a requirement that the control changes be easily observable. Rather, if the instrument gains traction and permanency then these will become recognisable to informed listeners over time. There are a selection of events in the suits repertory that involve larger gestures, but they are in the minority and the ongoing addition of gestures lies mainly in increasingly smaller movements.

Reflection and future work

At the outset of the system design a number of key impulses governed the thrust of the design. The key motivations to not pre-prepare audio, to not use a laptop-based system, to build technologies into the instrument and to interrogate notational practices were all born out of personal experience. In a sense the research has validated some of these desires and refined the nature of others in a practical way. What has been encouraging is that the system is becoming ever more 'usable' and the continual refinements are making it deployable in performance and collaborative circumstances.

In the first two concerts mentioned earlier in this paper the scale of the set-up procedures (seven hours in the first case) meant that the system was not practical and was, thus, confined to a very limited set of circumstances which would have constituted an impracticality. Currently the basic set-up time can be realised in a standard live context and this affords ease of use in performance. This flexibility means it can now be used to engage other opportunities on a more regular basis.

The next six months will be devoted to addressing a number of new research goals. These include development of the following:

- WiFi or Bluetooth connections for the exoskeleton: The suit has just been exposed to the first round of WiFi enabling, however, for reasons of lag it is still currently running cabled. Bluetooth may provide a solution in coming months.
- Software effects systems: The exoskeleton is now going to connect through software effects for ease of transport. With an increasing number of performances the weight and size of outboard equipment is proving to be prohibitive. This does not conflict with the 'no laptop' aesthetic as the materials will still be completely improvised.
- Engagement with a live engineer through digital consoles: A current research goal is to try to stage performances where effects automation (firstly volume and panning) on a live console could be automated through the performer exoskeleton. Many new digital mixing consoles have live automation (via an iPad, for example) and through advance planing and mapping the exoskeleton could control this.
- Collaborative effects improvisation: This would be an as yet unexplored aspect where dual mapping could occur. Where the Cyber-guitar system could, whilst performing itself, also be simultaneously mapped through another (willing) performer's effects matrix.
- Internet collaboration: Exploring the possibility of sending the exoskeleton controller data via the internet for collaborative live performance.

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