GuitarAMI and GuiaRT: two independent yet complementary Augmented Nylon Guitar projects

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ABSTRACT

This paper describes two augmented nylon-string guitar projects developed in different institutions. *GuitarAMI* uses sensors to modify the classical guitars constraints while *GuiaRT* uses digital signal processing to create virtual guitarists that interact with the performer in real-time. After a bibliographic review of Augmented Musical Instruments (AMIs) based on guitars, we present the details of the two projects and compare them using an adapted dimensional space representation. Highlighting the complementarity and cross-influences between the projects, we propose avenues for future collaborative work.

Author Keywords

Augmented Musical Instruments, Guitar, Nylon Guitar, Hexaphonic Pickup

CCS Concepts

•Applied computing → Performing arts; Sound and music computing;

1. INTRODUCTION

Augmented Musical Instruments (or AMIs) are created by embedding sensors and actuators on traditional instruments, allowing the performer to control and modify the instrument's sonic output [1].

However, due to physical differences, it is necessary to establish different approaches to augment electric or acoustic (including the classical nylon-string) guitars. Throughout the second half of the twentieth century, the classical guitar gradually began to use electronic sound manipulation processes, in situations predominantly linked to electroacoustic music. On the other hand, the electric guitar appropriated such manipulations as an intrinsic part of its performance practice. This instrument is one of most frequently used for augmentation, in part because of its popularity, but mainly because of the ease in adding further electronic components to it—since its inception, such elements belong to the essence of an electric guitar.

If we can think of electric guitar pedals as devices of timbre manipulation, we can conclude that the combination formed by the electric guitar, pedal boards and effect processors, along with the amplification system, presents a configuration comparable with most AMIs. Electric guitar pedals, however, are commonly seen as a regular part of the instrument and not an extension or enhancement of its characteristics. We can justify this understanding by considering that the effects used in electric guitars usually have one-dimensional control possibilities, like the Wah-Wah pedal, or only offer the option to activate or deactivate some previously configured process [2]. Therefore when we talk about AMIs, we usually refer to the use of sensors and actuators, as well as synthesis and sound manipulation processes using software and programming languages specifically designed for the task.

Hexaphonic pickups can also be considered as sensors used in augmentation. Built in both magnetic and piezoelectric formats, they are an integral part of some commercial guitar models and systems[1]. However, they are also found in AMIs that demand access to raw audio captured from each string and use algorithms for gestural acquisition [3]. Moreover, we can observe an increased interest in using actuators attached to acoustic guitar soundboards (active control), and these cases will be addressed similarly.

We organized this paper as follows: the next section reviews AMIs based on guitars. After that, we present the projects *GuitarAMI* and *GuiaRT*, based on nylon (or classical) guitars and independently developed by the authors. The following section compares both projects using a dimension space representation [4]. Finally, we present the next steps to be taken jointly by the two projects.

2. GUITAR-BASED AUGMENTED MUSICAL INTRUMENTS

2.1 Electric guitars

We can find several AMI projects built with electric guitars using direct or indirect gestural acquisition [3]: the *Situated Trio*, the *Smeck Guitar*, the *Mobile Wireless Augmented Guitar*, the *Multimodal Guitar*, the *Augmentalist*, the *Feedback Resonance Guitar*, the *RANGE Guitar*, the *UniCoMP*, the *Talking Guitar*, *Graham's Guitar*, and the *Fusion Guitar*.

Wessel and colleagues describes the *Situated Trio* [5], an improvised trio performance where one of the performers plays a Gibson electric guitar with a hexaphonic piezoelectric pickup. The authors explore both the analog audio outputs and the symbolic (MIDI) data acquired from the hexaphonic pickup in Max/MSP to control effects, including non-linear distortion, spatialization, overdub/looping processes, among others.

Puckette explored, with the *Smeck* guitar processing, the

[1]Such as Line 6 Variax guitars, Godin Synth Access, or Roland GK-3/GR-55 modules.

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new possibilities offered by the individualization of guitar string signals, using a Steinberger/Gibson electric guitar and a hexaphonic piezoelectric pickup [6].

Bouillot and colleagues' *Mobile Wireless Augmented Guitar* consists of an electric guitar, a Wii Remote attached to the guitar's head, an embedded microprocessor to perform a phase vocoder synthesis process, and a portable computer for processing the audio signal [7].

Reboursière and colleagues built the *Multimodal Guitar* using an electric guitar, a hexaphonic pickup, and three force-sensitive resistors (FSRs) installed on the back of the instrument. The played notes converted into MIDI signals and the data generated by the FSRs are sent to Max/MSP or to Pure Data to control preprogrammed sound manipulation algorithms [8].

Newton and Marshall's *Augmentalist* is not an AMI per se, but a platform for augmenting electric guitars using sensors (Phidgets[2]) and microcontrollers [9]. The authors proposed to analyze how performers used the resources made available by the Augmentalist to create customized AMIs for each performance.

Edgar Berdahl's *Feedback Resonance Guitar* uses dual embedded electromagnets to modify the electric guitar by exciting each string individually (active control), and a smartphone to generate control data for the used algorithms. Signals used to excite the strings include the guitar's sound (feedback loop), pre-recorded audio signals or other instrument's sounds acquired in real-time [10]. The goal is to create new timbres and textures, as well as use resonance effects as compositional support.

MacConnell and colleagues presented the *RANGE Guitar* as an AMI built with an electric guitar and variable (membrane) potentiometers, non-invasively installed on the instrument [11]. The embedded processor[3] receives the membrane potentiometers data to control a guitar effect patch programmed in Pure Data.

Hödl and Fitzpatrick's *UniCoMP* is a platform that allows the performers to send control data to a computer, using the sensors and the touch screen of mobile phones. This data is transmitted to a laptop and mapped within Max/MSP [12].

Donovan and McPherson presented the *Talking Guitar* [2]. The camera acquires the electric guitar position by tracking the movement of a ball illuminated by LED attached to the guitar's head.

Graham and Bridges used an electric guitar with multichannel pickup, along with a Kinect sensor, in the design of a gesture-driven system for spatial music performance, implemented in Pure Data [13].

The *Fusion Guitar* is an electric guitar embedded with an iPhone/iPod dock and a built-in speaker system. The iOS app can apply effects, emulate amplifiers, record or loop guitar sounds, and serve as a tutor system for learning to play the instrument [14].

2.2 Acoustic guitars

There are substantially fewer acoustic (steel or nylon-string) guitar AMI projects, including: the *SmartGuitar*, the *Lähdeoja's Augmented Guitar*, the *Angulo's Guitar*, the *Vo-96*, the *ToneWoodAmp*, the *Tonik Pulse*, the *Yahama TransAcoustic Guitar*, and the *Acpad*.

In the *SmartGuitar*, Mamou-Mani and colleagues used sensors, actuators, and microcontrollers to explore the body of an acoustic guitar as a loudspeaker, projecting a mix of the acoustic and synthesized—or digitally manipulated—sounds [15]. The SmartGuitar is part of a group of projects called SmartInstruments, which also includes cello and trombone. The HyVibe company released a crowdfunding campaign to realize the SmartGuitar as a commercial product.

The *Lähdeoja's Augmented Guitar* uses a hexaphonic pickup system[4] and audio exciters—electrodynamic actuators—produced by *Tectonics Elements* to achieve an outcome similar to the SmartGuitar. The pickup sends audio to a computer running Max/MSP for processing—granular synthesis, Modal feedback, and timbre modification using flute samples—and sent to the audio exciters attached to the guitar soundboard [16].

In [17], the authors set up a classical guitar with piezoelectric sensors for each string, and the audio signals are used for real-time estimation of fundamental frequencies and amplitudes. The data is fed to a graphical interface programmed in Processing.

The *Vo-96* is a commercial acoustic synthesizer developed by Paul Vo. The Vo-96 uses a magnetic transducer that converts the steel strings' energy into electric signals that are processed by the built-in analog and digital signal processing hardware [18].

Three recent commercial products use actuators to excite the body of the instrument, interacting with the natural sound of the acoustic guitar and modifying sonic characteristics to simulate traditional effects such as reverb, echo or delay. They are the *ToneWoodAmp*[5], the *Tonik Pulse*[6] and the *Yamaha TransAcoustic guitar*[7].

The *Acpad* is a wireless MIDI device that is designed to be attached to an acoustic guitar soundboard [19]. The device allows performers to interact with the instrument using a technique knows as *fingerstyle* to generate MIDI data.

Table 1 presents a summary of this section. It presents the AMI names, their augmentation goals, acquisition methods, and sensors. For the acquisition methods we use the gestural acquisition definition presented in [3]: 1) We have direct acquisition by using one or various sensors to convert the performer's gestures in control data, and 2) We have indirect acquisition when gestures are extracted from the sound produced by the instrument.

3. GUITARAMI

Acoustic musical instruments, although very versatile, have intrinsic sonic limitations due to their construction characteristics. For the classical nylon strings guitar, these constraints include short sustain and the lack of sound intensity control after the attack. *GuitarAMI* uses sensors that generate data from gestures to control algorithms that overcome some of these limitations [20].

From 2014, three *GuitarAMI* prototypes were built, which had been tested in performances and music education activities [21]. The second *GuitarAMI* prototype was also used in performance for the B.E.A.T.[8] trio (drums, trumpet and guitar)[9].

The first and second prototypes had four elements: a sensor module, the processing unit, audio interface, and computer. Both used a cable connection between the sen-

[2] Http://www.phidgets.com/.

[3] The Beaglebone (http://beagleboard.org/).

[4] Ubertar (http://www.ubertar.com/hexaphonic/).

[5] http://www.tonewoodamp.com/

[6] http://toniksound.com/

[7] https://usa.yamaha.com/products/musical_instruments/guitars_basses/ac_guitars/ta_series/index.html

[8] An acronym for *Brazilian Electronic Aleatorium Trio*.

[9] This performance can be seen at https://youtu.be/dUd-1iOh104.

Table 1: Summary of the classical / electrical AMI descriptions.

Name [reference]	Augmentation Goal	Acquisition method	Sensors
Electric Guitars			
Situated Trio [5]	Performance (Audio and MIDI)	Indirect	Hexaphonic pickup
Smeck Guitar [6]	Audio descriptors acquisition	Indirect	Hexaphonic pickup
Mobile Wireless Aug. Guitar [7]	Phase Vocoder control	Direct	Wii Remote
Multimodal Guitar [8]	Synthesis control	Direct and indirect	Hexaphonic pickup and FSRs
Augmentalist [9]	AMI construction platform	Direct	Various sensors (Phidgets)
Feedback Resonance Guitar [10]	Active/Feedback control	Direct and indirect	Touchscreen and accelerometer
RANGE Guitar [11]	Generate control data	Direct	Membrane potentiometers
UniCoMP [12]	Real-time audio manipulation	Direct	Touchscreen and accelerometer
Talking Guitar [2]	Control a specific audio process	Direct	LED and webcam
Graham's Aug. Guitar [13]	Spatial performance	Direct and indirect	multichannel pickup and Kinect
Fusion Guitar [14]	Embed trad. effects	Direct	Touchscreen and accelerometer
Nylon and Steel-string Guitars			
SmartGuitar [15]	Real-time sound manipulation	Direct	Footswitches
Lähdeoja's Aug. Guitar [16]	Real-time sound manipulation	Indirect	Hexaphonic pickup
Angulo's Aug. Guitar [17]	Generate control data	Indirect	Hexaphonic pickup
Vo-96 [18]	Embed trad. effects and active control	Indirect	Hexaphonic pickup
Acpad [19]	Generate control data	Direct	FSRs

sor module and the processing unit. The module used the ADXL345 accelerometer and the HC-SR04 ultrasonic sensor, while the processing unit had five footswitches and an Arduino Leonardo as the microcontroller. Wireless communication was implemented in the third prototype, using two RF transmitter-receivers (NRF24L01+). The audio processing was divided between a multi-effects processor and the algorithms executed by the computer. While the multi-effects processor was responsible for standard sound manipulations, such as distortion, delay, reverb and wah-wah, the computer running Pure Data was able to receive gestural data from *GuitarAMI* processing unit to control preset algorithms—as well as new algorithms made by performers or composers.

The current prototype (under construction—Figure 1) has embedded a new microprocessor into the *GuitarAMI* processing unit, using the Prynth[10] framework, while maintaining the footswitches and LCD. The sensor module communicates through Wi-Fi using OSC protocol, which allows *GuitarAMI* to interact with other devices and Digital Musical Instruments (DMIs) connected to the same network. We also replaced two sensors in the sensor module: the LSM9DS0 (Magnetic, Angular Rate and Gravity sensor—MARG) replaced the ADXL345 accelerometer, and the HC-SR04 ultrasonic sensor was replaced by the newer HC-SR04+, for better hardware compatibility.

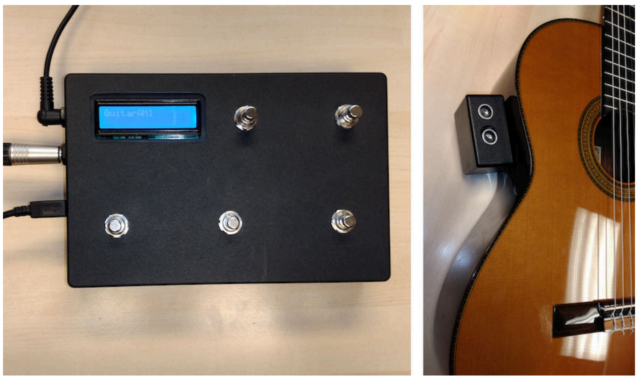


Figure 1: Current *GuitarAMI* Prototype. (a) Processing unit with embedded microprocessor and visual feedback; (b) *GuitarAMI* Wi-Fi sensor module and guitar body.

[10] `Https://prynth.github.io/`.

3.1 Interaction strategies

There are two *GuitarAMI* patches currently in use. The first patch (*Experimentos_0.3.pd*) presents spectral freeze, FM modulation, and looping capabilities; The second patch (*Time Machine*) uses time stretching procedures described in [22], particularly the *Direct FFT/IFFT approach*, already explored in tutorials and community patches (as can be found in Pure Data[11] and Max/MSP[12] forums).

The *Time Machine* is based on the *phase vocoder time bender* patch [23]. We have performed some modifications to allow the use of circular tables, that act as circular buffers, although storing audio in the frequency domain. The buffers store the last played minute. The *Time Machine* patch contains two operation modes: the *Freeze mode* and the *Delorean mode*. The Freeze mode, also available in the *Experimentos* patch, acts as a regular spectral freeze: the audio signal is analyzed and resynthesized from the blocks acquired immediately after the user activates the function, i.e., pushes the freeze button. The synthesized sound is windowed and constantly triggered, creating a continuous sound. The Delorean mode acts as time stretching by using two subpatches: the *buffer* and the *prepare_buffer*. The *buffer* patch stores audio data in the frequency domain using two tables. The *prepare_buffer* patch is responsible for reading the arrays and reproducing it with the *tabread4~* object.

During the performance with *GuitarAMI*, the performer can access the buffer containing what was performed during the last minute using two different methods. The first option is by using one of the footswitches to activate a sound resynthesis process—and control its duration—to hold the current sound output indefinitely. The second option is by performing gestures in front of the ultrasonic sensor to start time stretching operations in the buffer, using the most recent recorded information as the starting point. By moving the guitar (i.e., using the accelerometer/MARG), the performer can control the buffer reading speed.

4. GUIART

The *GuiaRT* was started in 2011 at the Center for Studies on the Musical Gesture and Expression (*CEGeME*), at the School of Music of the Federal University of Minas Gerais (UFMG), with the mounting of LR Baggs hexa-

[11] `Http://forum.pdpatchrepo.info/`.
[12] `Https://cycling74.com/forums/page/1`.

phonic piezo pickups on a nylon Spanish Alhambra guitar. Its primary purpose was—and remains—the development of a DSP-based acoustic-digital interface to be used in interactive musical contexts by guitarists, whose technical and creative abilities would be expanded using real-time extraction and manipulation of low and midlevel descriptors. As the available commercial packages dedicated to this task—the combination of hexaphonic pickups and low-level extraction—were expensive and closed systems, the decision was to program almost from scratch, feeding the raw 6-channel audio into the Max/MSP environment. Given the sound typologies afforded by the nylon-strings guitar[13], it seemed quite straightforward to focus on onset detection as the project's starting point. The first challenge was posed by the recognition of a strong mechanical coupling between the strings, mediated by the bridge and the top plate. This coupling can produce higher energy levels than the energy produced by soft strokes on a resting string. Thus, the first task was to seek to minimize these influences, using filters, and non-linear variable thresholds applied to six different 5-string sub-mixes. After that, the algorithms were able to detect onsets within a 10 ms margin error and to estimate amplitudes and durations. Quantitative analyses of different right-hand techniques have been accomplished with this setup, like tremolos, block chords, layer control and strumming.

In 2014, the project acquired a new guitar—a Yamaha CG182—and RMC pickups for both instruments. At that time, the connectors on the lower side of the guitars were also replaced with more robust XLR 7-pin connectors (see Figure 2). Further efforts were dedicated to the extraction of additional descriptors, such as fundamental frequencies, spectral centroids, slurs, harmonics, pizzicatos and vibratos/bendings. A similar approach can be found in [24]. As each extraction procedure has a different latency (counting from the detected onset), the global list describing an event is generated at its offset. The definition of several midlevel descriptors—extracted in real-time from short excerpts selected by the performer—came next [25]. Visual and aural feedback is offered to the guitarist.

Figure 2: (a) Guitar and (b) 7-pin connector used in *GuiaRT*.

Although *GuiaRT* was well equipped with sensing and processing procedures—according to Rowe's 1993 terminology [26], it still lacked a response module. Experiments with the direct audio captured in real-time were not successful: this was due not only to notable differences in timbre between the acoustic and captured sounds, but also to the inaccurate segmentation of slurred sounds, and mostly to the coupling among the strings. Therefore the decision was to use a specialized audio library—Ilya Efimov Nylon Guitar, which was able to deliver the different typologies extracted by *GuiaRT*, besides presenting a sound quality quite similar to those of the guitars in use. The use of this library allowed a symbolic approach to the response module regarding pitch classes, rhythmic values, articulations, among others. *GuiaRT's* main sound/musical identity is that of a guitarist improvising in duo or trio with him/herself. Short motifs or phrases may act as initial stimuli. Additionally, different signal processing routines may also be applied to individual string sounds, or even to a global sound (captured by a contact microphone). Among these procedures, the prolongation of notes, ring modulation, and audio processing using FM synthesis parameters [27] are worthy of mention.

GuiaRT has also been used in artistic and pedagogical contexts. In 2015, it was used in the multimedia concert *Kandinsky Sonoro*, by the group *Klang*, which used three paintings of the Russian artist as starting points for collective compositions.

4.1 Interaction strategies

During a performance with *GuiaRT*, the performer may select, using a switch pedal, specific excerpts for analysis and variation. Up to now, two "virtual" guitarists can perform the variations, making use of the audio library mentioned above. Each excerpt is stored as a list of events with their respective low-level descriptors. Just after the release of the pedal, the excerpt is analyzed and classified as one out of the seven crudely pre-defined textures: melody, arpeggio, sustained melody, counterpoint, melody with chords, percussive chords, block/strummed chords. Three midlevel descriptors are used for this classification: chord proportion, most prominent chord size, and superimposition index [25][14].

So far, *GuiaRT* has eight variation procedures to be applied to an excerpt. They may be roughly divided into two categories, one preserving rhythm and the other preserving pitch content. The inversion, shuffling and mirroring of strings are in the first category, as well as the imposition of a 4-element pitch-class set. There are two retrograding procedures; both applied independently to each string: one uses the onset times for reversing the time structure (and shifts the corresponding durations), the other transforms offsets in onsets—and vice-versa. Another rhythm variation is the shuffling of IOIs (inter-onset-intervals) and durations performed on each string. The variations may be cascaded at performer's choice.

The choice of variations is made by a weighted draw. The performer must define a range of weights (between 0 and 100) for each variation type, for all basic textures. This draw is repeated after the playback of a variation. The user may also shorten the set of available variations, or even alternate between pre-defined types. Any variation must be triggered in real-time. The considerable amount of symbolic data extracted by *GuiaRT* makes possible the definition of many different triggering strategies, ranging from immediate to texture-dependent triggers. A complete

[13] It is relevant to note that extended techniques—like percussion on different parts of the instrument, playing on the nut side of a stopped string or changing the size of the sound hole—are not well captured by these pickups, which are fixed as saddles on the bridge.

[14] Two projects that explore the *Disklavier* are worthy of mention here, due to their conceptual similarity to the *GuiaRT* setup. Both Risset's *Duet for One Pianist* [28] and George Lewis's *Interactive Trio* rely on the idea of a virtual performer, whose musical material is derived from the part played by a real performer.

performance plan using *GuiaRT* may include—besides the setting of parameters for low-level extraction, the choice of different variation and triggering strategies—also further modules for signal processing and spatialization[15].

5. CONTEXTUALIZED COMPARISON OF THE TWO PROJECTS

We can make some observations from the reviews in section 2: 1) There is an apparent division between AMIs that use loudspeakers and those which have body-coupled actuators for sound output; 2) AMI input signals can be of a diverse nature, including data generated by gestures, audio signals or even data extracted from the audio captures; 3) Sensors and computers can or cannot be embedded according to the AMI design. With these ideas in the background, it is possible to objectively compare the two projects using the dimension space[16] representation [4].

We will remove and adapt some axes to fit our comparison needs: The *Inter-actors* axis is redundant since both AMIs have the classical guitar in their construction and expect one user per system. The *Role of Sound* axis also can be excluded since both AMIs share the same category: artistic/expressive. We will also use two additional axes: the *Audio Output* axis will be employed to represent the number of outputs, varying continuously from “one” to “many”; and the *Gesture Acquisition* axis will be used to represent the acquisition method with discrete values: direct, indirect, or hybrid [3].

The *Musical Control* axis has its origins in [29], where different levels of control allowed by a sensor are discussed: 1) The *control over a musical process* corresponds to an abstract mapping that controls any desired process (macroscopic level); 2) The *note level* corresponds to discrete control of synthesis parameters triggered by an attack (orla level); 3) The *timbral level* corresponds to continuous control of synthesis parameters simultaneously (microscopic level). In [4] these three levels are discussed as discrete features; nevertheless, in the case of AMIs, the options may be more complex. Certainly, the performer must be able to control simultaneously the three levels while playing on the acoustic instrument (what demands, by itself, a high level of expertise); on the other hand, the augmented procedures may include one or more levels of control. For the present comparison, we have split this axis in two, one related to the continuous timbral control, which is highly correlated with the *Degrees of Freedom* axis, and the other to the control of musical processes. The two projects present symmetrical values for these axes: *GuitarAMI* has a refined control over timbral modifications, while *GuiaRT* offers a larger control over musical processes.

Both AMIs use the loudspeaker as main audio output, although presenting a significant difference between the routing capabilities. While the *GuitarAMI* only delivers one channel (mono output), the *GuiaRT* counts with a separate output and panning options for each—real or virtual—string.

Regarding the *Feedback Modalities* axis, the performer on *GuiaRT* does not need visual feedback to play along with the selected variations, although some functions may be displayed in the computer screen. The *GuitarAMI* provides visual feedback in both Pure Data patches and GuitarAMI’s processing unit LCD.

[15]Some video excerpts may be seen at `http://www.musica.ufmg.br/sfreire/wordpress/`

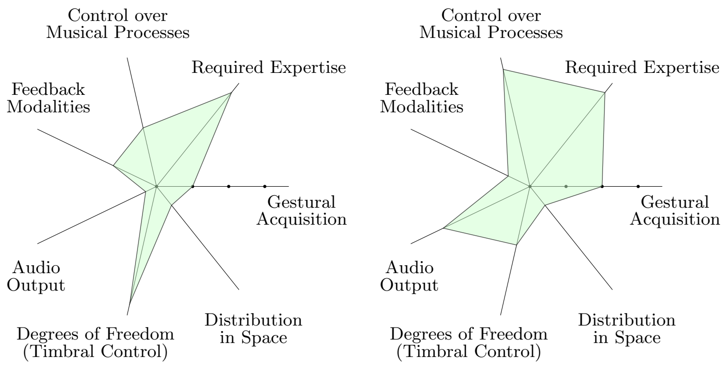
[16]The original dimension spaces axes are: *Required Expertise*, *Musical Control*, *Feedback Modalities*, *Degrees of Freedom*, *Inter-actors*, *Distribution in Space*, and *Role of Sound*.

Both instruments are very similar in spatial distribution: the performance occurs in a single location, and the performer interacts with a single AMI built around the nylon-string guitar.

In the *Gestural Acquisition* axis, we can perceive a conceptual difference between the two AMIs. Since *GuiaRT* uses the signals produced by the strings as the main data acquisition method, it has no impact on the performer’s traditional gestures. Still, the performer needs to use at least one footswitch to control several procedure parameters. *GuitarAMI* uses data from the embedded sensors (IMU and ultrasonic) to process the audio signal, but no control is extracted from the audio. We can say that, in this aspect, the systems are complementary and they can incorporate each others control data acquisition process.

Figure 3 depicts the dimensional space plots for each project.

Augmented musical instruments share a common question: How should the richness and the expertise of performances on acoustic instruments with the sonic/expressive possibilities allowed by new technologies be integrated? Distinct projects propose different responses for these challenges, and most of them tend to blur the borders of the roles traditionally assigned to performers, composers, builders/programmers, and audience. Both *GuitarAMI* and *GuiaRT* demand from performers not only instrumental expertise but also commitment to creative and technological issues. In our opinion, the emergence of these new and alternative ways of making and performing music are equally important as the new sounds obtained from the augmentation processes.



(a) *GuitarAMI* (b) *GuiaRT*

Figure 3: Dimension Space Plots.

6. CONCLUSIONS AND FUTURE WORK

By analyzing the dimension space plots, one can readily perceive that the *GuitarAMI* restrictions are met by the *GuiaRT* and vice versa. With this complementarity in mind, it is expected that a collaboration between projects can expand the distinct possibilities of the AMIs and reduce their restrictions. Besides the use of augmented nylon guitars, another critical link between *GuitarAMI* and *GuiaRT* is the fact that they are developed in laboratories that have been performing international research collaborations for about a decade. Hence, it is natural to expect mutual influences between them. As discussed in the last section, *GuiaRT*’s central core is highly dependent on specific hardware—a modified guitar, an audio interface and a computer running Max-MSP. Despite that, some of the algorithms in use may be easily converted to alternative programming languages. On the other side, *GuitarAMI* is more portable, since the processing unit and sensors may function with several setups.

These characteristics can be used to define the first steps of a productive collaboration: on *GuiaRT*'s side, the data generated by continuous sensors will help to refine sound processing algorithms; for *GuitarAMI*, the use of symbolic data may also help to refine some processes of selecting segments for audio manipulation. Both projects will profit from cross-examination and adaptation of the sound processing routines in use, including spatialization. Moreover: shared creative processes—in co-located or remote forms—will undoubtedly reveal new paths not only to this starting cooperation but also as a resource for other nylon-string based AMI projects.

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