The Electrobass: A New Electronic Instrument Inspired By The Bass Guitar

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ABSTRACT

The Electrobass is an instrument that takes inspiration from the interface of the bass guitar, but is in fact a flexible synthesizer. The Electrobass has roots in instruments like the SynthAxe, the Casio DG series, and other commercial guitar synthesis instruments, but applies this mindset to the bass guitar with a new approach. The technology is closely related to the authors' Electrosteel[6] instrument, and the Electrobass was developed simultaneously as an alternative form for the underlying idea. This paper outlines how the goals of the Electrobass differ from the Electrosteel, and what changes from that paradigm the bass guitar's interface demands.

Author Keywords

bass, Electrobass, synthesis, guitar, interface

CCS Concepts

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

1. INTRODUCTION

The project was inspired by a musical problem that arose in the first author's live band, Owen Lake and the Tragic Loves. The electro-country band has a synth-pop inspired sound, with the bass lines on the recordings realized using synthesis. However, when playing live, it was more visually interesting to have a bass player than a keyboardist, and many of the bass lines were programmed with musical gestures that were more idiomatic for the bass guitar. Surveying the lack of acceptable commercial solutions to the problem led to the development of the Electrobass. Beyond filling this type of role, the goal of the instrument was to provide another way to access synthesis control, one that took advantage of the specific techniques of bass players, with the hope that the instrument would eventually be appropriated for other uses the authors didn't imagine[10].

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Many experimental instruments have explored this concept in the past. Examples that model stringed instruments with ribbon interfaces date back at least to the "Fingerboard Theremin" created by Leon Theremin in the early 1930s[1]. More recent projects that have a similar spirit are the BoSSA[8] and the XTSynth[5]. Several NIMEs directly approach the interface of the electric guitar, if not the electric bass, including the GXtar[4] and the commercial products of the Starr Labs MIDI Guitars[1], which includes a MIDI bass. Taking a wider view of the subject, Harrison[2] dives into an enlightening experiment with several guitar-like interfaces to determine how much input modality vs global form create musician's perceptions of an instrument.

2. IDENTIFYING IMPORTANT INTERFACE ELEMENTS OF THE BASS GUITAR

Since the goal of this project was to harness the embodied skill of expert bass guitarists for control of electronic synthesis, the first step was to determine which elements of the interface were important to preserve, and which could be simplified or ignored. The most obvious important points of interaction with the bass guitar are the right hand plucking the strings and the left hand fretting the strings at different points along the neck to select pitches. As this project was undertaken simultaneously with the development of the Electrosteel, we aimed to reuse the same technology for both wherever possible.

In many ways, the right hand interface is very similar between the electric bass and the pedal steel guitar (PSG), which was the model for the Electrosteel. The strings are plucked and damped, and both plucking amplitude and the moment of damping need to be sensed to achieve a reasonable model of the plucking action. However, while the PSG has metal fingerpicks on each finger (and a thumbpick), the bass is played either directly with the fingers or with a flatpick, and both of those interaction behaviors were deemed important to preserve.

The left hand on an electric bass presses the strings against the fretboard. Unlike the PSG, where a single bar moves along all strings, and this interaction can be sensed with either a single point along the neck or two points interpolated across the neck, on an electric bass, all four strings could be fretted at independent points, requiring individual sensing.

While the PSG has many more additional interface elements to contend with, such as knee levers and pedals, the electric bass is much simpler, with two knobs completing the compliment of salient interface elements. There are several other details that enable the use of these interface elements, such as the shape of the body and how it positions the neck and the strings with relation to the player, but as for the

[1]https://www.starrlabs.com/product/zbass/

Figure 1: The most recent Electrobass prototype, rev3

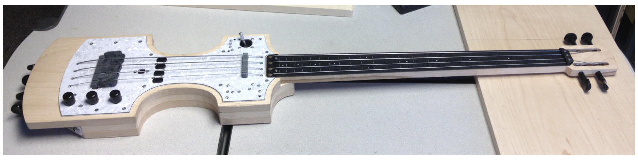

Figure 2: An earlier Electrobass prototype, rev2

direct interface, there is little else to emulate.

3. THE ELECTROBASS INTERFACE ELEMENTS

Early on in the development of this project, some design decisions had to be made about the concept of the instrument. Commercial guitar synthesizers exist, and many of them serve the purpose of putting electronic synthesis under the control of a guitarist. The most well-known versions do synthesis by converting the signal from an actual guitar, fitted with individual per-string pickups, into midi signals that can control a synthesizer. While this can work acceptably for a guitar, doing pitch detection on signals in the bass guitar range involves large latencies, making this approach unsatisfactory for bass players. Additionally, if part of the goal is to have a more synth-like control over elements of the sound like envelope, a pitch-tracking approach means that the envelope decay length is limited by the decay time of the physical string; Once it has stopped ringing you lose the ability to track it. The desirability of extremely long sustain times and the difficulty of pitch-tracking the bass register were decisive in driving this project toward an abstracted approach to the interface, where the left and right hand systems are sensed independently.

3.1 Right Hand Sensing

For the right hand, it was quickly determined that using actual strings, spaced as they are on a bass guitar, would give the most playable emulation of the right hand interface. Four short strings are positioned under the right hand, with their own bridge and nut, both on the body. Attack detection is done in a manner similar to the Electrosteel, with single-string electromagnetic pickups sending signal through an ADC to a microcontroller running an attack-detection algorithm. After attacks, the next feature of right-hand plucking that must be distinguished is a muting action. If the player touches the string with the right hand after plucking it, the vibration is stopped. In the Electrobass, as with the Electrosteel, we detect this gesture with capacitive touch sensing, using the string itself as the conductive sensor. While this works very well in the Electrosteel, where the player traditionally has metal picks on each finger, this can be less reliable on the Electrobass. Unfortunately, working professional bassists tend to have calloused fingers from playing, and this reduces the conductivity of the fingers for the capacitance sensing. This is a problem that we are still

Figure 3: P.A. Tremblay tests a rev2 Electrobass prototype

Figure 4: The Electrosteel fingerboard sensor

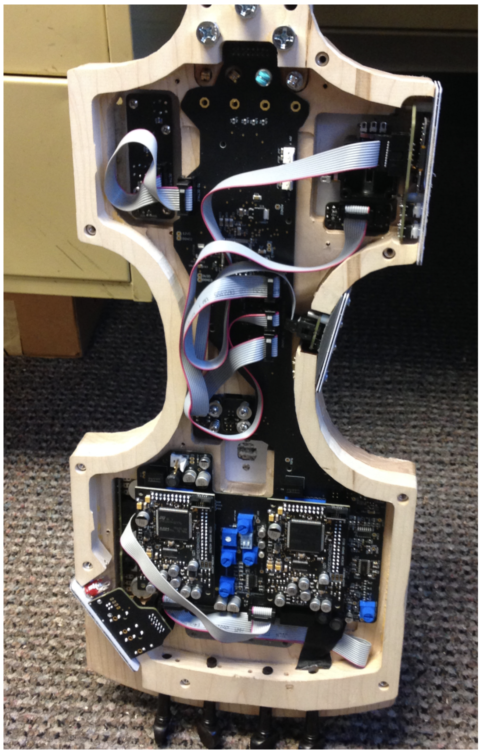

Figure 5: Electrobass rev2 internal circuitry

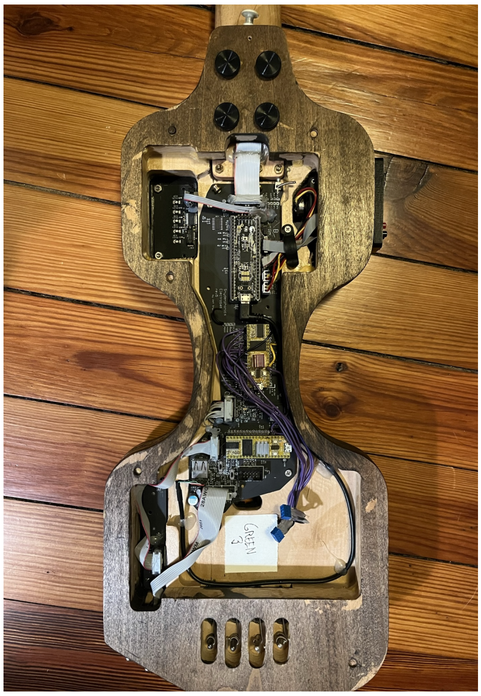

Figure 6: Electrobass rev3 internal circuitry

aiming to solve.

Another concern is that this type of mute sensing doesn't work with standard plastic flatpicks. Metal picks do work with the sensing technology, but they feel much stiffer than standard picks and require adjustment of technique.

3.2 Left Hand Sensing

On the left hand of the Electrobass, our primary goal is to sense the position of the fingers on each string. We set out with the goal that Electrobass could be both fretted and fretless, with a button to change the naturally fretless behavior into a quantized "fretted mode". Therefore, we aimed to sense continuous position rather than discrete steps. This was also motivated by a desire to use the same technology between both Electrobass and Electrosteel, and the Electrosteel required continuous linear sensing. As with the Electrosteel, we created a custom PCB with resistive carbon ink, and designed a sensing system using a constant-current DAC (see the Electrosteel paper for details).

One major technique that is crucial for bass but not for the PSG is left-hand muting. A bass player, in addition to sometimes muting strings with the right hand, can also mute strings with the left hand by lifting the finger up to release the string from the fretboard, while still touching the string enough to damp its vibration. The solution on the Electrobass is to have the left-hand strings also be capacitive sensors, registering touch. Now, three states can be sensed. (Table 1)

This allows for naturalistic bass playing technique, with one caveat. The transition between state 3 and state 2 should result in a stable note being muted, but the fretboard sensor registers the lifting of the finger as an increase in resistance as the states change. This reads as a drop in

Table 1: Left Hand States

State 1	fingerboard not touched + string not touched	= open string
State 2	fingerboard not touched + string touched	= left-hand mute
State 3	fingerboard touched	= fretted note

Figure 7: Sideband performs "Semaphore" for Electrobass quartet and Electrosteel at Wesleyan University

pitch before the mute, as it can't be disambiguated from a downward slide without additional sensing.

A solution to this problem was found[2] by adding a second ADC channel reading the voltage on the opposite end of the resistive strip. When the finger is lifted off of the fretboard, the resistance increases on both sides of the strip, but when the finger slides downward, the resistance increases on the body side, but decreases on the headstock side. This allows for disambiguation of the two gestures.

One interesting aspect of the "quantized fretting" option is that the frets can be set to any arbitrary tuning system. The player can play as though in equal temperament but the instrument can snap the pitches to any alternate tuning the player desires.

4. SYNTHESIS

The Electrobass is designed with the same onboard synthesis circuitry as the Electrosteel, and is similarly programmed with the Electrosynth plugin developed by the authors.

5. RESULTS

So far, 6 copies of the current Electrobass prototype have been constructed. A piece, called "Semaphore", for a quartet of Electrobasses, accompanied by Electrosteel, was composed by the primary author and performed by electronic music ensemble Sideband on a tour in the Spring of 2023.

In "Semaphore" the performers on the instrument were not bassists, but approached the instrument with excitement and were able to play it confidently after a week of rehearsals. However, the performances took place before the "left hand mute" glitch mentioned above had been solved, so avoiding that glitch was a distraction. The instruments were used in "quantized fretted" mode with an alternate Just Intonation tuning, which allowed for some beautiful and unusual harmonies across the instruments. At the performers' request, the authors added a mode where vibrato is allowed to pass through the fretboard quantization, and they found that increased the expression greatly.

One clear success of the instrument was that the avoidance of pitch-tracking and the integration of embedded synthesis helped it achieve a very low latency. All players who tried the instrument remarked that they could perceive no delay in the response. Measurements on the current prototype show a latency measurement from the sensor attack to the start of the synthesis audio output to be around 6ms, well within the generally cited bounds of acceptable latency for a digital musical instrument[9][3], which is usually placed at 10ms with +/-1ms jitter.

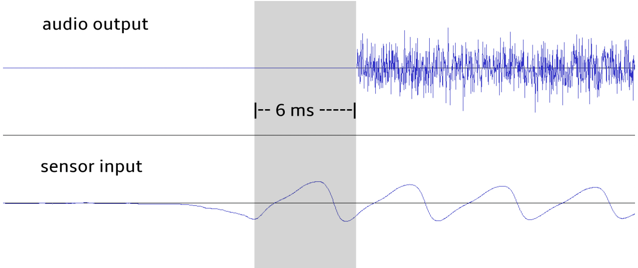

Figure 8: A test recording of the sensor input to audio output latency

6. FUTURE WORK

One powerful expressive parameter on an electric bass is plucking position on the string. We currently have no sensitivity to this on the Electrobass, so incorporating a system that could detect pluck position is a future goal, perhaps taking inspiration from Temprano[7], as sensing the angle of the string could also determine the pluck position.

Other potential sources for useful sensor data would be a sensor that detects a palm pressed against the bridge, or the addition of an IMU to sense position of the neck.

We are currently working to find a way to improve the mute sensing for players with calloused fingers. That remains the most significant stumbling block to the success of the instrument at its original goal.

The next step in the Electrobass project is to get the instruments into the hands of players and collect feedback. This will be happening over the next year.

7. ACKNOWLEDGEMENTS

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8. ETHICAL STANDARDS

This project was undertaken within the standards of the NIME ethical code of conduct.

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