An Adapted Bass Guitar for One-Handed Playing

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ABSTRACT

We present an attachment for the bass guitar which allows MIDI-controlled actuated fretting. This instrument adaptation is presented as a potential method of augmenting the bass guitar for those with upper-limb disabilities. Following a survey of 48 bassists, we found that timbral and dynamic features related to the plucking hand were most important to the survey respondents. We designed an actuated fretting mechanism to replace the role of the fretting hand in order to preserve plucking hand techniques. We conducted a performance study in which experienced bassists performed an accompaniment to a backing track with the adapted bass. This highlighted ways in which adapting a fretted string instrument in this way impacts plucking hand technique.

Author Keywords

Accessibility, one-handed instruments, robotic instruments, bass guitar

ACM Classification

K.4.2 [Computers and Society] Social Issues – Assistive technologies for persons with disabilities H.5.5 [Information Interfaces and Presentation] Sound and Music Computing

1. INTRODUCTION

The majority of traditional western musical instruments are designed to be played with both hands. Even for instruments such as the piano which can be played one-handed, the written repertoire generally requires two-handed playing. This is clearly prohibitive to musicians with upper-limb disabilities who wish to participate in music performance with a traditional instrument.

In collaboration with the One-Handed Musical Instrument (OHMI) Trust[1], we designed a prototype adaptation for the bass guitar which allows mechanical fretting of the strings via foot control, leaving the plucking hand available for string excitation. Here we present our design, based on similar work and the results of a player survey, followed by the results of a performance study with the bass.

[1] http://www.ohmi.org.uk/

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2. BACKGROUND

Larsen presents a review of existing accessible musical instruments [4]. Of these, one in particular is related to one-handed playing, being the Actuated Guitar [3]. Other accessible guitar instruments include the guitarMasheen [6], a fully-actuated acoustic guitar with an iPad interface, and the KellyCaster[2], designed by John Kelly and members of Drake Music. The OHMI Trust present winners of their annual one-handed instrument design competition, featuring many examples of accessible and adapted instruments[1].

Kapur's review of musical robotics discusses projects which involve mechanical approaches to fretting and plucking [2].

3. PLAYER SURVEY

We conducted an online survey of 48 bassists in order to discover what players felt were the most important aspects of bass guitar playing. We asked participants to rank ten different performance elements in terms of their importance to playing bass. The respondents' emphasis on elements related to the plucking hand (rhythmic accuracy, rhythm choice, dynamics, plucking hand articulation) suggests that for bass guitar, much of the expression of the instrument comes from the plucking hand. This was echoed by one respondent's comment that 'you could do so much simply by sticking to the [root notes] and differing where, how and how hard you play the notes'. Details of the survey, the instrument and performance study will be available in a forthcoming paper [1].

4. ACTUATED FRETTING MECHANISM

The results from our survey suggested that preserving the role of the plucking hand would also preserve the most important aspects of bass playing. We opted to replace the fretting hand with an actuated fretting mechanism, and transfer note selection to the feet via a MIDI controller. Our fretting mechanism consists of a series of clamps which attach to either side of the neck, and hold six pull-type solenoid motors perpendicular to the fretboard. This is a prototype design using a limited number of frets to test our concept. The solenoid plungers are attached to the tip of the fretting arms, which are fixed onto a threaded metal rod on the opposite side of the neck, acting as a hinge. A spring return at the base returns the fretting arms to the rest height once the solenoid is deactivated. Figure 1 shows a schematic of the design.

We used the Bela platform [5] to drive the solenoid motors and to communicate with the MIDI controller. The Arturia Beatstep's[3] grid layout allows notes to be mapped similar

[2] http://www.drakemusic.org/our-work/research-development/artist-led-projects/john-kelly-the-kellycaster/

[3] https://www.arturia.com/beatstep/overview

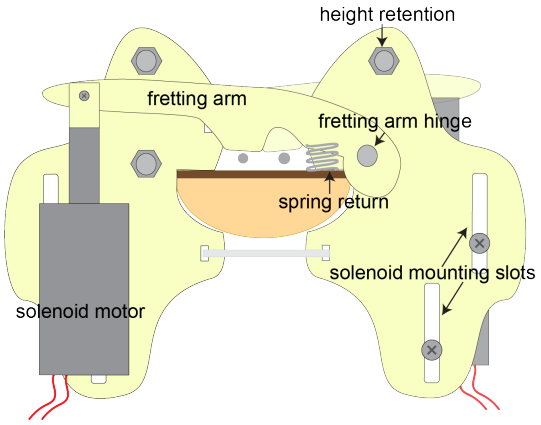

Figure 1: Final neck clamp design

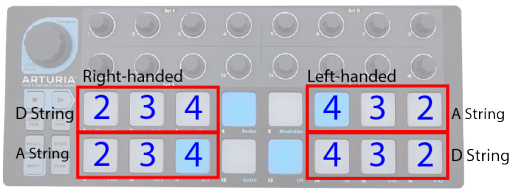

Figure 2: Mapping layout for Arturia Beatstep

to the layout of a fretboard, with columns for fret position, and rows for strings. This is based on Norman's 'natural mapping' approach [7]. Figure 2 shows the mapping layout we used. We added a reversed layout for a left-handed player who took part in the study.

We measured the system for latency by placing a piezo sensor underneath the contact with the fretting arm and another taped to the corresponding pad on the controller. We then measured the delay between the piezo's voltage change onsets when the button was pressed, using a digital oscilloscope. Over ten recordings, we recorded an average latency of around 54 ms.

5. PERFORMANCE STUDY

Our performance study featured six bassists, who were instructed to compose and rehearse an accompaniment to an eight-bar backing track, for a minimum of two hours, spread over three weeks. Once the participants had finished preparing their accompaniment, we recorded audio and video of their performances. They then filled in a questionnaire detailing their responses to the instrument's usability and how they felt it had affected their technique.

A key finding was the way in which participants responded to the lack of fretting-hand muting functionality. With two hands, the strings can be muted with the fretting hand following string skipping or to shorten the notes for staccato playing, by gently touching the strings to stop vibration. This is impossible with our fretting system due to the binary nature of the solenoid motors. We noticed that the four performers who used a finger-picking style all used their plucking hand to perform these functional mutes, resulting in an adaptation of their plucking hand technique. Of these, one of the participants gave a particularly notable performance, appearing to have gained sufficient control over this extended technique after two hours of rehearsal. Another participant used an alternate approach: consistent palm-muted plucking with a plectrum. This was an interesting example of a performer using a fairly typical bass playing technique as a response to the limitations of the system.

The questionnaire highlighted players' subjective responses to the system. Most participants pointed out the difficulty in using the feet for such a precise task, but two commented that the interface was intuitive to use. Participants were invited to discuss the extent to which common bass techniques were possible with the adapted bass. Most agreed that gestures such as string bends, slides and dead notes were impossible with the system. There was disagreement between participants on the possibility of achieving hammer-ons. Two stated that hammer-ons were easy or intuitive to achieve, whereas another said they were possible but not controlled, and another commented that they were impossible to play. This is perhaps a function of terminology: the idiosyncratic attack and amplitude of the mechanical hammer-on is quite distinct from a typical hammer-on with the hand. This could also be a function of the system latency: 54 ms might be tolerable when using the fretting system for note selection, but less so when used for note onset during mechanical hammer-ons. This agrees with Wessel and Wright's quoted 10 ms upper limit for latency tolerance in DMIs [8].

6. CONCLUSION

Our prototype bass guitar adaptation and subsequent study highlighted ways in which musicians adapt their technique when the role of a particular hand is transferred to an alternate limb in this way. The user study also highlighted successes and limitations of this approach, which we hope will inform future accessible string instrument adaptations.

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