Aalborg Universitet

AALBORG UNIVERSITY

A Wearable Foot-mounted / Instrument-mounted Effect Controller

Design and Evaluation

Konovalovs, Kristians; Zovnercuka, Jelizaveta; Adjorlu, Ali; Overholt, Daniel

Published in:
NIME 2017 Papers and Posters Proceedings

Publication date:
2017

Link to publication from Aalborg University

Citation for published version (APA):
Konovalovs, K., Zovnercuka, J., Adjorlu, A., & Overholt, D. (2017). A Wearable Foot-mounted / Instrument-mounted Effect Controller: Design and Evaluation. In *NIME 2017 Papers and Posters Proceedings* (pp. 354-357). NIME. http://www.nime.org/proceedings/2017/nime2017_paper0067.pdf

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy
If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from vbn.aau.dk on: July 04, 2025

A Wearable Foot-mounted / Instrument-mounted Effect Controller: Design and Evaluation

Kristians Konovalovs
Aalborg University
Copenhagen
christiankonovalov@gmail.com

Jelizaveta Zovnercuka
Aalborg University
Copenhagen
elizabeth.etalart@gmail.com

Ali Adjorlu
Aalborg University
Copenhagen
adj@create.aau.dk

Daniel Overholt
Aalborg University
Copenhagen
dano@create.aau.dk

ABSTRACT

This paper explores a new interaction possibility for increasing performer freedom via a foot-mounted wearable, and an instrument-mounted device that maintain stomp-box styles of interactivity, but without the restrictions normally associated with the original design of guitar effect pedals. The classic foot activated effect pedals that are used to alter the sound of the instrument are stationary, forcing the performer to return to the same location in order to interact with the pedals. This paper presents a new design that enables the performer to interact with the effect pedals anywhere on the stage. By designing a foot&instrument-mounted effect controller, we kept the strongest part of the classical pedal design, while allowing the activation of the effect at any location on the stage. The usability of the device has been tested on thirty experienced guitar players. Their performance has been recorded and compared, and their opinion has been investigated through questionnaire and interview. The results of the experiment showed that, in theory, foot&instrument-mounted effect controller can replace standard effect pedals and at the same time provide more mobility on a stage.

Author Keywords

Foot&instrument-mounted effect controller, Digital signal processing, Effect pedal

ACM Classification

B.4.1 [Data Communications Devices] Receivers (e.g., voice, data, image) and Transmitters, B.4.2 [Input/Output Devices] Image display, H.5.1 [Multimedia Information Systems] Audio input/output, H.5.5 [Sound and Music Computing] Signal analysis, synthesis, and processing.

1. INTRODUCTION

Nowadays, well-known devices are being redesigned and improved for more comfort and usability. Basing on Moore's law, the opportunities and possibilities of the electronic devices are increasing, while their size is decreasing [1]. However, some of the devices in more specific areas are keeping their original design since their invention, for example, electric guitar and especially its hardware, e.g. effect pedals. Even though effect pedals are easy to use and are very efficient, they are limiting performers, forcing them to return to the same location to switch effects on/off, or to sit down to change some pedal settings. This works against visual attractiveness of the show. Initial empirical work has been carried out in order to map performer's preferences and needs when interacting with effect pedals during shows. The research led to the creation of foot&instrument-mounted effect controller, which gave the possibility to carry it and activate effects at any place on a stage. This prototype has been created, tested and evaluated on a group of skilled musicians, e.g. guitar players.

The paper is organized as follows: section 2 presents the most interesting already existing redesigns of the effect pedals, which influenced the concept of our prototype. It leads to the section 3, where the design and implementation of the foot&instrument-mounted effect controller is discussed. In the section 4 we briefly present the overall goals and methods used for carrying the experiment and gaining results, which are in detail described in section 5. In section 6 we discuss the results and finally in section 7 we present possible development of the prototype.

2. RELATED WORKS

As the effect pedals are mostly used by guitar players, during our research we were looking for any kind of device that was carried by guitar player during the performance.

One of good examples is implementation of the Hot Hand device, which is based on leap-motion technology [2]. It consists of effect box and special bluetooth ring, which provides the control over the effects. The advantage of this idea is that the effect can be controlled anytime and anywhere on the stage. The setup is effective, and it is very easy to learn how to use it. The limitation of this technique is that the control over the effects is motion-based, and it can't really be permanent. This is perfect for some real time sound synthesis and filtering only. Also, the control over the effect can barely be held during playing, so you either play the guitar, or control the effect. However the idea of involving wireless technology for controlling effect seemed very efficient. Hantrakul & Kaczmarek [3] investigated the possibilities of using leap-motion as a tool for effects modulation and as-

Licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). Copyright remains with the author(s).

NIME'17, May 15-19, 2017, Aalborg University Copenhagen, Denmark.

sistive performance. The setup is very simple and easy to learn. Unfortunately, the guitar players have to be located in front of the leap motion sensor, resulting in a lack of mobility. Nevertheless, this setup can be a good inspiration of how the effects can be alternatively controlled.

Developers of Korg Kaoss pad and Roland GK3 pickup [4] also made some impact on finding an alternative to classical pedal effects. The first one, Kaoss pad, is a small guitar-mounted effect processor, which has a library of different effects and few touch pads for controlling them. The second one, Roland GK3, is a special pickup which turns the sound of the guitar into midi signal. Though it is not closely related to the effects, this special pickup is connected with a small controller, which is placed on the guitar, also providing some control over the sound.

Keith McMillen expanded the usage of the effect pedals. A good example of his innovations is Softstep, foot-controlled stationary device. It gives additional control over the sound and the effects by implementing gesture-sensitive pads, which track pressure and position of the foot. While classic stompboxes require only vertical movement for activation and deactivation, Softstep reacts on different axis as well, which provides far more nuanced control over the effect [5].

The majority of above mentioned solutions are instrument or body mounted, which did not anyhow link a performer to one place, and provided some new features in addition. However, all these technologies require hands to be used for controlling them, which may cause some discomfort as hands are busy while playing.

In conclusion it was decided to make an instrument-or-body-mounted wireless device, which would give control over the effects, without worsening the playability of performer, therefore, hands should not be used to activate the effects.

3. DESIGN & IMPLEMENTATION

The design process went through basic user-centered interaction design cycle [6] and consisted of two iterations. The first device consisted of two different parts, both being attached to the body of an instrument. The first part was a small box with nine potentiometers which let performer to alter effect settings. Second part had three buttons and it was used for switching effects on and off. The buttons had visual feedback so they shone when the effects were on. The first prototype was thoroughly analyzed and tested on multiple performers, specifically, guitar players. The results showed that the effect-adjustment box was very efficient. Visual feedback of buttons was definitely an advantage as well. However the idea of switching effects on and off by pressing the buttons was not acceptable as performers' hands were busy with playing. All these observations led to the list of requirements for the next high-fidelity prototype:

- Activation of the effects performed by foot
- Allow performers to alter the settings of the effects
- Four effects should be implemented - Distortion, Delay, Reverb and Wah-wah.
- Acceptable sound latency (not more than 12ms [7])
- System should be wireless
- Strong visual feedback
- Should be small and durable

For the second prototype, it was decided to have three separate devices. The first device should be mounted on performers' foot and be used for managing the activation of the effects. The second device should be mounted on the instrument and provide the control over the effect settings. The third device is supposed to work for sound processing and receive values from the first and second devices. Wifi was chosen to work for the connection. Based on the results from a number of contextual inquiry sessions conducted on 4 guitar players, the essential elements of the design were established [6].

3.1 Device 1

The first device was based on NodeMCU module. Adafruit 10DOF gyroscope was connected to it and performed the traction of performer's foot. In order to switch effect on or off, the device should have been activated first. It was done by tilting the foot to the right side, which is also known as inversion movement (Figure 2).

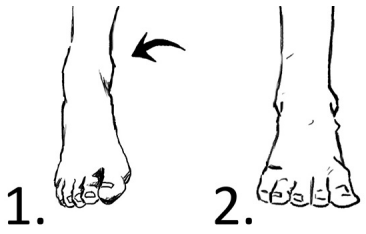

Figure 2: Visual representation of the inversion movement needed for the system activation.

After performing the inversion movement, performer could rotate his foot left or right in order to choose the effect s/he wanted to change. When the choice was made, the toe should had been lifted up and then pushed down, which imitated the usual usage of effect stomp-boxes. When the toe reached the floor, the effect was instantly switched on or off depending on its previous state.

To control wah-wah effect, the reversed movement was chosen, e.g. raising and lowering heel. This way of controlling wah-wah effect was inspired by Keith McMillen's

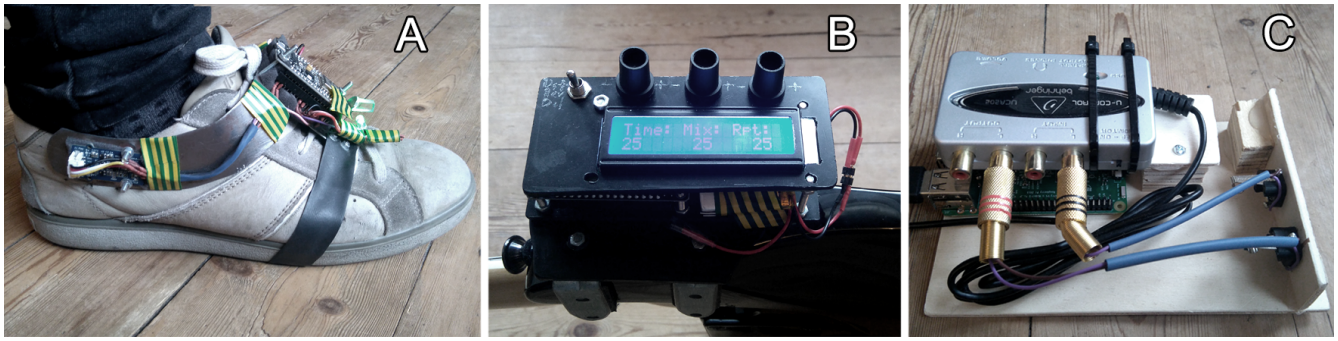

Figure 1: Device 1 (A), Device 2 (B), Device 3 (C).

Softstep [5]. The finalized device can be seen on the Figure 1(A).

3.2 Device 2

Second device was also based on NodeMCU, and consisted of LCD screen, three encoders and switch. Based on data gained from usability testing conducted during the first iteration, it was decided that the device should be compact and easy mountable to the instrument. Three encoders and switch made it possible to easily alter settings of the effects. LCD screen provided information about the adjustments of the effects. The design and concept of this device 1(B) was based on advantages of the previous prototype.

3.3 Device 3

Third device was based on Raspberry Pi 3, as it had enough computational power for real-time sound processing. As an advantage, it had built-in wifi module. Behringer UCA202 was used as ADC/DAC. Pd-extended worked for sound processing. Java server was running on Raspberry Pi in order to filter received data. Four effects were implemented: delay, reverb, distortion and wah-wah. The finished device can be seen on the Figure 1(C).

4. GOALS & METHODOLOGY

The overall goal of the research was to find out, if foot&instrument-mounted effect controller can negatively influence the performance of the musician. If there is no difference in the quality of the performance, it would mean that the usability of the prototype is high enough to make foot&instrument-mounted effect controller competitive with classic effect pedals. To find out, a within-group method was used, which is more sensitive then between-group method [8], e.g. 30 experienced performers, specifically, guitar players were asked to perform a specific song twice - one time using effect pedals and other time using foot&instrument-mounted effect controller. To minimize bias, a randomization method has been used [9], e.g. half of the test participants started with effect pedals and the other half with foot&instrument-mounted effect controller. Then a t-test was performed. It compared the results of the performers when using the effect pedals with the results of the same people when using foot&instrument-mounted effect controller. Additionally, interviews were conducted to understand the subjective opinion of the target group about their experience. Performances of test participants have been recorded both when using effect pedals and foot&instrument-mounted effect controller. Finally, data logging has been used to objectively evaluate the quality of the performance and, especially, time required to activate the effects.

5. EVALUATION

The experiment has been conducted in order to answer two main questions:

- Can foot&instrument-mounted effect controller be competitive with usual effect pedals (are there any negative influences in the performance created by the design)?
- Can foot&instrument-mounted effect controller provide more mobility on a stage, compared to usual effect pedals?

5.1 Testing procedure

The test participants were asked to learn a part of a simple and popular song, in order to reduce possible skill-biased experience. They were explained, when and what effect should be activated or deactivated. To avoid carry-over bias, half of the test participants started with the effect pedals, and the other half - with foot&instrument-mounted effect controller. Their performance has been recorded. Finally, the participants have been asked to fill in questionnaire and participate in an interview.

5.2 Results

As there were two main questions to answer, the results are presented in three different sections: (1) Questionnaire results, (2) Usability and (3) Mobility.

5.2.1 Questionnaire results

The questionnaire was mostly focused on user experience and usability of the prototype. Almost all test subjects liked the setting box and its location on the guitar, but agreed that it has to be smaller. However, all of the components of the setting box were relevant. Test participants also liked the RGB LED shining bright and having no latency when choosing the effect. However, as there was only one LED which switched off after activating the effect, it became disturbing to always keep in mind what effects were activated. Therefore, couple of test participants wanted an LCD screen to display not only settings, but also the effect chosen by the switch device, which would make the device feel more comfortable and user-friendly. The activation move for the device was comfortable for a half of the test participants, as it cannot be made unexpectedly and, thus, is reliable; and was inappropriate for the other half of test participants, as it is impossible to use it with the specific types of shoes, such as ankle boots with very hard leather.

Finally, switching two side effects was difficult for some of the test participants, as there was timer, which gave approximately one second of additional time after activating the effect to switch on/off more effects. For some test participants it was hard to make it on time, and for others additional time sometimes ended up in accidentally switching on effects they did not want to.

5.2.2 Usability

Basing on the results of the questionnaire a t-test has been performed. The results showed that there was a significant difference in performances, when switching between effect pedals and foot&instrument-mounted effect controller. It means that the redesign of the classic effect pedals provided better level of comfort for performers and influenced the performance even less than the effect pedals. Interviews showed, that the concept of the foot&instrument-mounted effect controller was appreciated. Moreover, basing on the responses, it provided more mobility on a stage, than the effect pedals.

In order to get the objective data on the effectiveness of the foot&instrument-mounted effect controller, the performance of the test participants has been recorded. Then the recording was quantized in order to obtain a rhythmically perfect track. The raw version of the recordings was compared to the quantized version, resulting in the overall level of the performers imprecision in performance, which could be caused by the design. The data gathered has been analysed using the Wilcoxon test. The results indicated that there was no significant difference between the two groups. Therefore, it can be concluded that the foot&instrument-mounted effect controller did not influence the performance of performers.

5.2.3 Mobility

After each case of the experiment interviews were conducted in order to gather the subjective opinion of the test partici-

pants and reveal strongest and weakest parts of the design. Most of the test participants agreed that having the effects close during the performance allows to use all stage space. While the effect pedals forced performers to stay in the specific range to be able to activate or deactivate the effects at the right time, foot&instrument-mounted effect controller solved this problem.

6. DISCUSSION

The evaluation showed that the suggested foot&instrument-mounted effect controller provided musicians with mobility during live performances. Fortunately, the level of playability when using our prototype seemed to be competitive with classic effect pedals. However it was also agreed that the test could be re-done in order to obtain more reliable data. The target group should be specified more for this test, as, though we had thirty experienced players to test our prototype out, their experience with pedals was completely different. The test could be done with two different target groups - people who are experienced with guitar pedal effects and people who are not. Another topic that can be mentioned is type of shoes a performer wears. If it is not elastic enough and does not allow to perform inversion movement, the prototype can not be used properly, which obviously is a drawback. Moreover, according to the questionnaire results, additional RGB LED could be used for clearer visual feedback. Finally, the timer system could be reconsidered.

7. CONCLUSION & FUTURE WORKS

Effect pedals have not been redesigned since their invention. Their disadvantages, such as restrictions in mobility and discomfort in adjustment of the effect, have not been eliminated, what resulted in a creation of a brand new effect device. Foot&instrument-mounted effect controller took strongest parts of original stomp-box design, such as activation of the effect with foot, and at the same time solved multiple problems of classical pedal designs. The testing session proved its efficiency and a possibility of becoming a good alternative to the classic effect pedal design.

The foot&instrument-mounted effect controller still has a big room for improvement. For example, not only four effects might be implemented, but a lot more, forming a library of different effects. Currently, a performer can only operate with four effects, however this number can be increased as well. During the experiment, couple of participants claimed that it would be a great idea to use this device not only for managing effects, but also visual parts of the stage e.g. smoke, lights etc.

8. REFERENCES

[1] Ilkka Tuomi. The lives and death of moore's law. *First Monday*, 7(11), 2002.

[2] Wayne Siegel. Conducting sound in space. 2016.

[3] Lamtharn Hantrakul and Konrad Kaczmarek. Implementations of the leap motion in sound synthesis, effects modulation and assistive performance tools. In *ICMC*, 2014.

[4] Enda Bates, Dermot Furlong, and Donnacha Dennehy. Adapting polyphonic pickup technology for spatial music performance. In *ICMC*, 2008.

[5] Alex Maiolo. Keith McMillen instruments: Not your parents' MIDI controllers: Review of kmi's quneo, 12 step, SoftStep MIDI expander. Jan/feb 2015.

[6] Helen Sharp, Yvonne Rogers, and Jenny Preece. Interaction design: beyond human-computer interaction. 2007.

[7] Michael Lester and Jon Boley. The effects of latency on live sound monitoring. In *Audio Engineering Society Convention 123*. Audio Engineering Society, 2007.

[8] Andy Field and Graham Hole. *How to design and report experiments*. Sage, 2002.

[9] Ralph B d'Agostino. Tutorial in biostatistics: propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Stat Med*, 17(19):2265–2281, 1998.