Drumtastic: Haptic Guidance for Polyrhythmic Drumming Practice

ABSTRACT

We present *Drumtastic*, an application where the user interacts with two Novint Falcon haptic devices to play virtual drums. The purpose of the study is to explore if guided haptic feedback can help the user learn polyrhythms with guided feedback. The application's visual structure is composed of two virtual cursors (corresponding to the Falcon devices) as well as two virtual drums: a snare and a hi-hat. When the user hits one of the instruments' surfaces with the virtual cursor(s), a corresponding sound is played. Upon starting the application, the user can enter the desired beat that will be mimicked by the haptic devices (e.g. a 5-over-4 polyrhythm in 100 beats per minute). The user also has the possibility to switch off the guidance and practice on their own.

A pilot experiment with six users was conducted, and the results indicate that learning to play polyrhythms with haptic guidance is feasible. However, longer term studies need to be conducted to validate this indication.

AUTHOR KEYWORDS

Haptics, HCI, polyrhythms, polyphonic rhythms, drumming, haptic guidance

ACM CLASSIFICATION KEYWORDS

H.5.2 User Interfaces: Haptic I/O

INTRODUCTION

Learning to play polyrhythms (the use or an instance of simultaneous contrasting rhythms) is arguably one of the harder ordeals within all aspects of drumming. Several famous drummers, especially within the progressive rock genre, use them to create rhythmically complex music. While using haptic vibrations to learn polyrhythms and drumming is an explored subject [2], using haptic guidance as a rhythmic learning tool is unexplored.

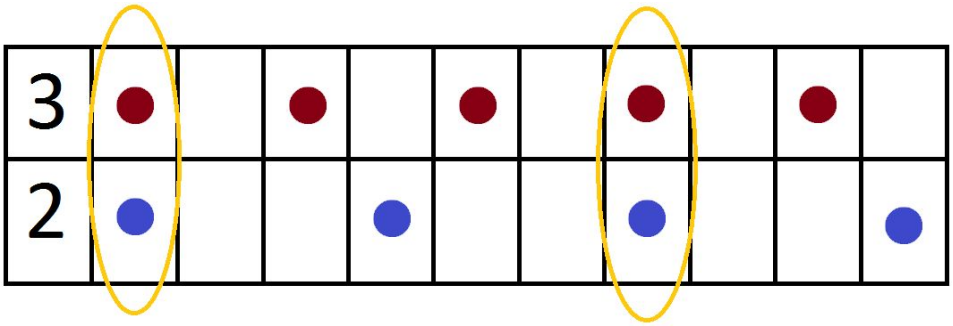

Figure 1. Visual representation of a 3-over-2 polyrhythm: the top row is one limb, the bottom row is another limb. Each dot represents a hit. The beats converge on the first beat in each respective rhythm, represented by the ovals.

The time signature for polyrhythms can be visualized with a diagram such as Figure 1. In a 3-over-2 polyrhythm, one of the beats plays three hits while the other plays two hits in the same amount of time. This results in the fact that the slower rhythm, the 2 in this case, completes at a pace ⅔ of the speed of the quicker rhythm. In this paper, we name the upper row beat (e.g. the 3 in Figure 1) the "main beat" and the lower row the "polyrhythm beat".

This paper investigates how haptics can be used in a musical learning process. More specifically, we look at a solution of using two Novint Falcon haptic devices to guide the user while learning desired rhythms.

THE DRUMTASTIC HAPTIC GUIDANCE PROTOTYPE

The setup consists of two Novint Falcon haptic devices connected to a desktop computer with Ubuntu OS. The simulation software is built with the C++ program language. For graphics and haptic simulation, the Chai3D library is used. The BASS audio library is utilized for audio playback.

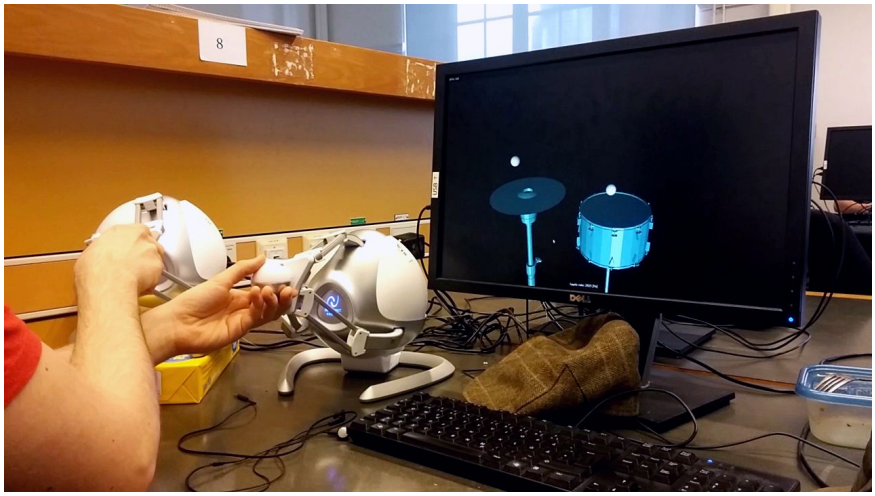

Figure 2. Image of the setup.

In the simulation, the user can hit the virtual snare drum and hi-hat by moving around the cursors (see the small white balls on the screen in Figure 2) with the Falcon devices. When a cursor hits a drum surface, a short sound clip plays depending on which object that was hit, and an upward force is applied by the haptic device. This mimics the feeling of hitting a real drum or hi-hat and receiving a rebound feedback, which gets stronger the harder the user hits the drum. The loudness of the audio playback also depends on the striking speed of the hit.

At the startup of the simulation, the user is prompted to type the desired main beat (essentially the hi-hat), polyrhythm beat (the snare drum) and the BPM, beats per minute. The simulation then calculates the rhythm which the Falcon devices haptically mimic. In this mode, the *Training Mode*, the user is supposed to grab the device knobs and let the devices act as guidance. The user can switch between this mode and a *Free Mode*, where the user can play freely on the drums without any guidance from the Falcon devices. This lets users try out the feeling of the haptic feedback from the virtual drums without guidance.

TECHNICAL LIMITATIONS OF DRUMTASTIC

The Novint Falcon Haptic Device has limitations in its ability to simulate realistic environments, mainly because of two reasons: precision and strength. A real-world drum has an extremely sharp haptic feedback from the drumstick hitting the drum, depending on how taut the drum is. The Falcon does not have the ability to give the exact type of feedback that a real-world drum gives, because of its lack of strength and precision. Therefore, creating an entirely realistic drum feeling is close to impossible with these devices.

However, while this indeed complicates the creation of a realistic drumming simulator, this is not our main concern. Since the focus on the study is teaching users to play specific (poly)rhythms, and not creating a realistic drumming simulator, this problem is of less importance. Polyrhythms are not restricted to being played on the drums, e.g. percussive gestures on one's chest or snapping fingers can also be polyrhythms. However, it is possible that haptically realistic drums provide a better user experience.

METHODS: PROTOTYPE ISSUES AND USER TESTING

The system was initially tested by three users to find major design flaws and usability problems. During these tests the users were allowed to try out the simulation in any way they wanted, with the objective of finding problems with it. The two main problems which were discovered were:

- The drum surfaces were too small, often resulting in the user missing the drum while playing.
- When simultaneously hitting the drums, the audio playback was not simultaneous, resulting in confusion about whether the user played it right or if the problem was in the simulation.

After addressing these initial problems, the system was tested on six users. They first explored the simulation in order to try out the haptic feedback. When they felt they were familiar with the system they were told to use the training mode until they could play the rhythm by themselves.

All users were asked to play a 4-over-1 rhythm, 3-over-2 polyrhythm and 4-over-3 polyrhythm. We supervised the test sessions, determining whether the users managed to learn the rhythms. All users managed to learn to play the rhythms. User 4 excelled at learning the rhythms, and played an additional polyrhythm, a 5-over-3 polyrhythm, because they thought it was fun. After using the system the users were asked about their musical background and how well they think users can learn with the system. System Usability Scale (SUS) questions were also asked, to determine if users could enjoy using a drumming simulator with haptic guidance.

RESULTS

User 1 and 6 did not actively play instruments, user 5 played the keyboard, users 2 and 4 played both the guitar and keyboard and user 3 played guitar, keyboard and drums. As for whether or not they knew how to play polyrhythms; user 1 and 2 could not or had not tried previously while the rest knew how to play at least one polyrhythm prior to the test (Table 1).

User	*Which instruments do you actively play?*	*Could you play a polyrhythm before the test?*
1	None	Don’t know/Never tried
2	Guitar, keyboard	Don’t know/Never tried
3	Guitar, keyboard, drums	Yes
4	Piano	Yes
5	Guitar, keyboard	Yes
6	None	Yes

Table 1. User answers regarding instruments actively played and ability to play polyrhythms.

All participants managed to learn the rhythms during the test sessions and agreed that they had learned the polyrhythms. They also believed they could learn additional ones if they had sufficient time using the system (Figure 3). The average for the first and second questions were 4.0 and 4.8, respectively.

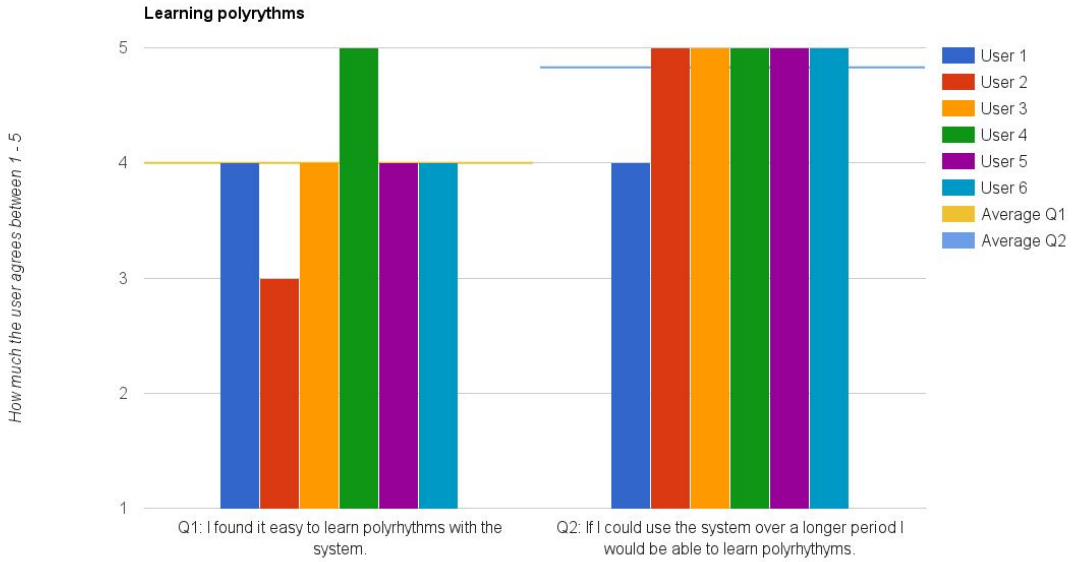

Figure 3. Bar chart showing the users' answers about learning polyrhythms with Drumtastic.

When the users were asked to score how much each modality helped in learning how to play the polyrhythms they answered with an average of 2.0 for the visuals, 3.8 for the haptics and 4.5 for the audio. After a while during the test sessions, many of the participants started to look away from the computer screen and instead relied solely on the haptic guidance as well as the sounds created by hitting the virtual drum set.

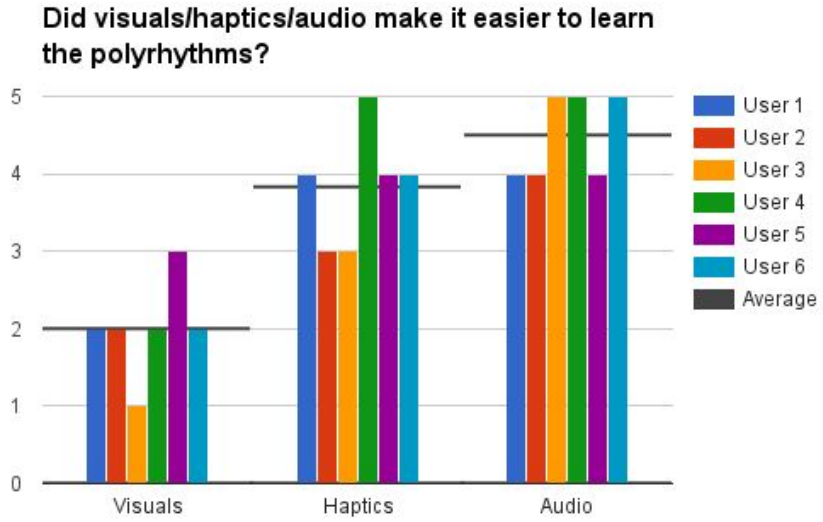

Figure 4. Bar chart showing how helpful the users thought each modality was for learning polyrhythms.

The users were asked questions from the the System Usability Scale (SUS) questionnaire. In Figure 5, we observe that Drumtastic scored an average of 83/100 points. The average SUS score is 68. To receive an A grade within SUS, a system needs to score over 80,3 [1].

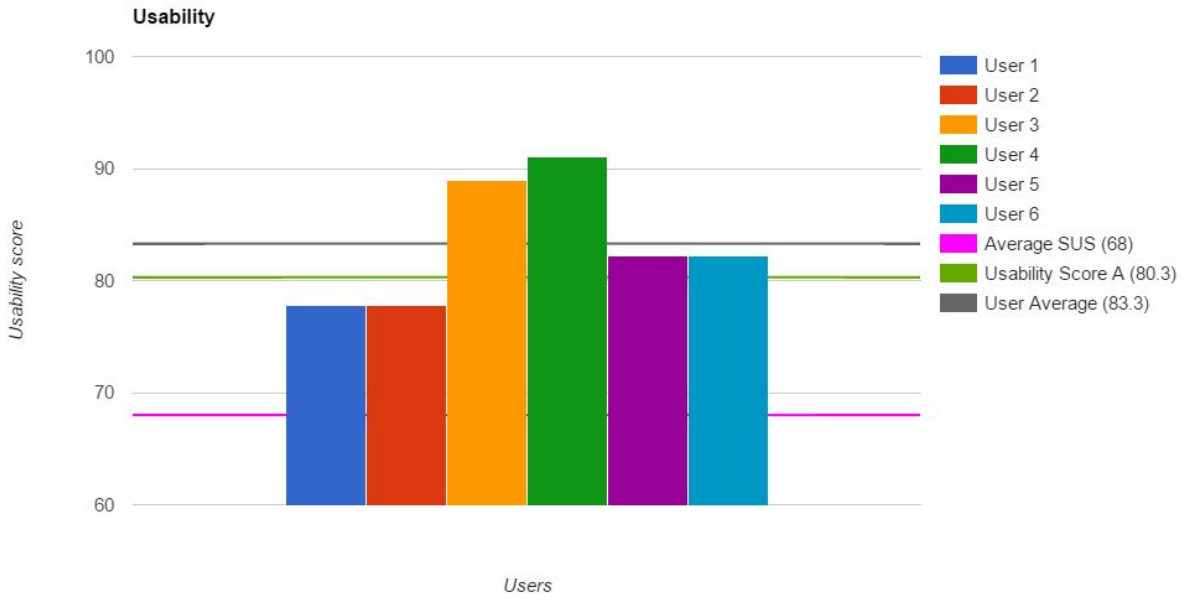

Figure 5. Bar chart showing users' individual SUS scores as well as thresholds for average SUS score (pink line), A grade SUS score (green line) as well as the average user rating (grey line).

HAPTIC GUIDANCE AS A RHYTHMIC LEARNING TOOL

Using haptic feedback to practice drumming and polyrhythms is a relatively unexplored field of research. However, a closely related system to Drumtastic, *The Haptic Drum Kit*, utilizes four vibrotactile devices on the wrists and ankles of the user. These tactile devices vibrate when the user should play with the respective limb [2]. Whereas this project uses tactile feedback in order to teach the user how to play, Drumtastic uses force feedback in order to physically force the user to play the correct rhythm.

Smus, B. and Gross, M. has investigated a setup where the user wears a tangible musical interface while doing simple drumming exercises on the chest, knees etc. By adding sensors on suitable parts of the user's clothes, simple drumming can generate real drum sounds when hitting these sensors. Even if the study didn't contain any thorough evaluation, the project did receive a large amount of positive feedback [3].

Drumtastic's average SUS score was 83, which is 2.7 points above the required score for an A grade. However, it is worth noting that the users were given instructions and directions during the test sessions, which might have increased the overall SUS score since it helped the users. User 3 pointed out as an extra comment that they thought they would have needed some type of tutorial to be able to use the system if they did not receive verbal instructions.

After a while during the test sessions, many of the participants started to look away from the computer screen and instead relied solely on the haptic guidance as well as the sounds created by hitting the virtual drumset. In general, haptic feedback is very important to play music at an expert level while visual feedback is not. Professional musicians do not require visual feedback of their limbs to control their movement [4]. Consequently, it is possible that there is a connection between learning to play music pieces proficiently and not having to use visual feedback to do so. Furthermore, it would therefore be relevant to investigate whether removing visual feedback provides a faster or slower learning process when using haptic guidance.

While usability scores and questions about system longevity indeed seems promising for Drumtastic, there needs to be more statistically significant research (i.e. more users) done with haptic guidance for learning polyrhythms, to sufficiently support this method of learning. Additionally, as long-term effects were not observed, the process of learning several and maybe also harder polyrhythms using haptic guidance is required to claim that users can learn advanced polyrhythmic drumming with haptic guidance.

In addition to validating the usage of haptic guidance to teach users how to play polyrhythms, it would be a natural continuation to compare haptic guidance to a vibrotactile haptic system such as *The Haptic Drum Kit* [2]. It is possible that when using haptics for the purpose of learning rhythms or drumming, guidance is not the optimal way of conduct. If both long and short term effects were to be observed for both systems, conclusions could be made about which system is superior for learning within this field.

Ultimately, we cannot know for sure if haptic feedback is an effective way of learning polyrhythms. It is possible that drumming lessons with a teacher or using only audial feedback such as the experiment conducted in *Ubiquitous Drums* [2] is cheaper or more practically feasible than using haptic feedback.

CONCLUSION

In this paper, we looked at how haptic feedback can be used to simplify the learning process of playing drums, more specifically playing polyrhythms. Additionally, we investigated the user experience of the system to determine if users could enjoy using the system. We developed a haptic drumming guidance system called Drumtastic, which utilized two Novint Falcon haptic devices as interface, and conducted user tests to evaluate the importance of this system. The results indicate that learning to play polyrhythms with haptic guidance is feasible. However, a longer term study needs to be conducted to validate this indication. Also, we propose that further research within the importance of visual feedback during haptic musical learning would be of interest.

REFERENCES

1. Measuringu.com, (2015). *Measuring Usability with the System Usability Scale (SUS): MeasuringU*. [online] Available at: http://www.measuringu.com/sus.php [Accessed 2 Jun. 2015].

2. Holland, S., Bouwer, A., Dalgelish, M. and Hurtig, T. (2010). Feeling the beat where it counts. *Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction - TEI '10*.

3. Smus, B. and Gross, M. (2010). Ubiquitous Drums: a Tangible, Wearable Musical Interface. *Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems - CHI EA '10*.

4. Zappi, V., Pistillo, A., Calinon, S., Brogni, A. and Caldwell, D. (2012). Music expression with a robot manipulator used as a bidirectional tangible interface. *EURASIP Journal on Audio, Speech, and Music Processing*, 2012(1), p.2.