

# Reflections on the Design of ToeTapper, a Foot-Operated System for Musical Performance and Composition

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## Summary

This paper describes the design of ToeTapper, a loop-based musical performance and composition system with a non-traditional interface using a "physical computing" approach. In contrast to desktop music systems, interaction takes place on the floor. Sensors and switches allow users to operate the system entirely with their feet or, if they prefer, by sitting on the floor and using their hands. The system's display is projected onto the floor, where users can touch visual sound objects directly to control them. The user doesn't directly interact with anything that "looks like a computer" at all – in fact the host system can be completely hidden away.

## Introduction

Although music technology products have the potential to be enjoyable, educational and beneficial to a very wide range of people, in general they are designed for a narrow range of musical experts and technophiles. Software and hardware products are often complex, difficult to learn or expensive. Even the simpler desktop options rely on traditional interaction techniques and devices which exclude or discourage many users.

The rest of the paper describes the inspiration behind the design of ToeTapper, followed by the implementation of the initial prototype. Finally we describe the user evaluations conducted so far.

# The Design of ToeTapper

ToeTapper is a real-time looping sampler with a novel interface. Real-time loopers allow users to capture (“sample”) sounds and repeat them in loops, creating layered sample-based music. This allows solo performers to build up complex sounds and rich textures totally live, without relying on backing tracks or computers. Although the roots of this technique lie in the use of tape loops in the 1950s and 60s, in recent years these units have evolved into complex instruments such as the Oberheim Echoplex, introduced in 1994.

## Initial Concept

The guiding aim behind the ToeTapper system was to create an application which took account of what it feels like to play an instrument (specifically the electric guitar, but taking others into consideration), and which built the composition process around this. Hence, all sounds were to be recorded in real time by the user.

The intention was that the user would play their instrument until they arrived at a satisfactory musical phrase. Then, without the need to stop playing, a foot switch would be tapped at the beginning and end of a single cycle of the phrase. Sound captured between the two taps would then be looped continuously, and further elaborations could be overdubbed on to separate audio channels, in sync with the first.

Recognising that the physical space a guitarist occupies (standing, walking around – it can be several square metres at least) is on a totally different scale to the space occupied by someone sitting at a computer screen, the system’s interface was to be scaled up until it became part of the guitarist’s natural space. Projecting a display onto the floor, where effects pedals are customarily placed, would allow loops of sound were to be represented in this natural workspace.

## Musicians and Music Technology

As well as being driven by the authors’ own enthusiasm for music technology, development of ToeTapper also involved users during requirements gathering and evaluation of the initial prototype.

During requirements gathering four musicians were interviewed, all with over 10 years’ experience with music hardware and software. Two of the interviewees orient their musical process around software. One has cerebral palsy and uses computers to make music from necessity, not having the co-ordination to play a conventional instrument. Another works mainly with guitar. All four use a combination of hardware and software to make music.

The format of the interviews was fairly free-form: the aim was to get the participants to discuss the way they use music hardware and software, with a particular emphasis on the physical interaction, and then to investigate ways in which they thought changes of interface could help them with this.

In terms of their attitudes towards their equipment, all of the musicians expressed fondness for a particular piece of hardware that they use to make music, while most felt indifferent about or sometimes frustrated with their music software. One mentioned some sound design he’d done using a synthesizer, and found it difficult to imagine getting involved in the sound to the same extent using a computer. Along similar lines, another mentioned the pressure he felt even switching his PC on – that until he switched it off again, ‘this is a recording session’; he thought that synthesizers on their own didn’t create the same sense of inhibiting self expectation in the user. Two spoke about the limitations of a screen display, where a bewildering array of small scale controls and the limitation of only being able to affect one of them at once detract from usability.

In general, most considered aspects of “working with a computer” to be limiting, overly-complex or even inhibiting to creativity.

Although our sample was small, the responses reflect common attitudes amongst musicians: that traditional ways of interacting with music software are often too complex, “fiddly”, disembodied, unsatisfying, and ultimately have negative effects on the creative process. Whereas hardware devices, even though they’re “machines”, are more direct, trustworthy and gratifying to use. Discussing why he doesn’t use software in the studio, renowned musician and producer Brian Eno says:

“it's a physical reason. [...] The only part [...] that's engaged is my mouse finger and eyes. My body starts to feel so... oof, I just want to hit something or bounce around on the floor. My experience of computer mixing, which I've had more experience of than any other form of computer work, is that it creates a cautious, perfectionistic way of working. I've banned computers in the studio, actually. It isn't because I'm anti-computer. It's because nobody understands them well enough.” (Toop, 1995; p128)

Mike D of the Beastie Boys echoes the tangible aspect:

“[...] there's just something about the tactile element of having the pads there on a machine and pounding out the beats by hand. There's a satisfaction to that which you don't quite get if you're clicking on your mouse in a step sequencer or in a MIDI window. You'll get to the same place, but the process just isn't as much fun.” (Steuer, 2004; p187)

The irony here of course is that with modern equipment, musicians often **are** in fact using a computer inside a keyboard, sampler and so on, even though they consider these devices to be different from general-purpose “computers”. The immediacy and tangibility of a specialised control interface, plus the “invisibility” of the computer inside the equipment, seem to be paramount in bringing about this change in attitude.

Thus we might conclude that a system that doesn’t “look like a computer” and which provides rich physical or tangible interaction for the user should be more satisfying for the musician.

In terms of the design of computer-based systems in general, the growing interest in tangible/physical computing, and the increasingly common “disappearing” or “invisible” computer (Norman, 1998) both underline how emphasis is moving away from general-purpose personal computers, towards specialised devices and systems tailored to performing a smaller set of tasks well. These new approaches, with their inherent focus on matching systems to human capabilities, provide new opportunities to promote and practice inclusive design.

## Tangible Interfaces

One of the earliest and most influential tangible interfaces, the DigitalDesk (Wellner, 1991), attempted to combine the tactile advantages of paper with the document editing advantages of a word processor. Instead of a monitor, a camera and projector were suspended above a desk, with the projector producing the display on the desk (or papers etc. lying on the desk), and the camera tracking movements made on the desktop.

In recent years a number of computer music instruments have been concerned with the representation of sound physically in a way which is very like the representation of paper on the DigitalDesk. The “reactTable” system (Kaltenbrunner, O’Modhrain & Costanza, 2004) uses no screen at all, but an area on a table surface. Objects in the shape of circles, stars, squares and cubes are placed within this area, and their position, proximity to one another and orientation, detected again by an overhead video camera, affect the sound produced. Other systems which use blocks on a table to represent sound include loopqoob (Konar, 2003), Audiopad (Patten, Recht & Ishii, 2002) and BlockJam (Newton-Dunn, Nakano & Gibson, 2003). (AudioPad’s

projected representation of loops had some influence on the visual design of ToeTapper's interface.)

## Foot-operated Systems

The computer music instruments mentioned above are primarily concerned with tactile objects, to be manipulated with the hands, but from the outset ToeTapper was conceived as a foot-operated system, leaving the hands free to play instruments. Pearson and Weiser (1986) discussed foot controls, again in the context of the desktop workstation, and provided a list of some fourteen examples of their use, including “the pipe organist’s bellows and footkeys, [...] the potter’s kickwheel, [...] wah-wah and fuzz pedals for guitars” (p333-334). They noted that feet can be used to transmit “power and control”, although compared to the hands they provide more power and less control.

In the years since Pearson and Weiser’s discussion there has been very little development in foot-based interaction until very recently – computer instrument designers included. Even an instrument such as the SensOrg (Vertegaal and Ungvary, 2001), whilst it completely surrounds the user in a “musician’s cockpit” (p311) of input and output devices mapped to various sounds and effects, is still entirely hand-operated. In the late 1960s, the American electronic rock duo Silver Apples created a machine called The Simeon (named after the singer), which similarly surrounded the player with switches, connected to oscillators and other devices such as an analogue Echoplex pedal: “The Lead and Rhythm oscillators are played with the hands, elbows and knees, and the bass oscillators are played with the feet” (Silver Apples, 1968). In using the feet to play bass-lines they clearly took the pipe organ as a model, but applied the idea to a collection of electronic equipment. However, this is a rare example.

Some more recent examples of foot-operated systems include a pair of shoes containing sensors which are used to transform movement into music while dancing in them (Paradiso, 2002) and a joy-pad that can detect foot movements for use in games (Rekimoto and Wang, 2004). On a much simpler level, but far more common, some computer games use foot-based interaction. A wide range of driving games for computers and game consoles will work with peripherals featuring foot pedals plus a steering wheel, while an increasing number of dancing games can make use of a “dance mat” on the floor which is capable of crude measurement of the user’s position.

Given the prevalence of foot control amongst devices for guitarists (and to a lesser extent, other musicians), plus the general lack of reported experimentation with foot-based input to computer systems, we concluded that a foot-operated interface would be worth exploring.

## Implementation of the Initial Prototype

Figure 1 shows the ToeTapper prototype as it was set up during the first phase of user testing. At top left can be seen the video projector, producing the display on the floor (centre). The host system, a Macintosh G4 desktop system can be seen under the table with a set of external speakers. To the top right of the “screen” are the foot pedals (see also Figure 2b). Finally on the right can be seen a range of instruments provided to participants.



Figure 1. ToeTapper System as set up for first phase of user testing.

Nine foot-controls are used to operate the system: four pressure sensors underneath the screen for channel selection, plus four push-switches and an analogue pedal control (Figure 2b) for recording, mixing and altering loop length. These are connected to an Infusion Systems I-CubeX digitizer, which converts the analogue voltages from switches and sensors into digital MIDI data that can be read and interpreted by the computer. The digitizer connects to the computer via a USB MIDI interface.

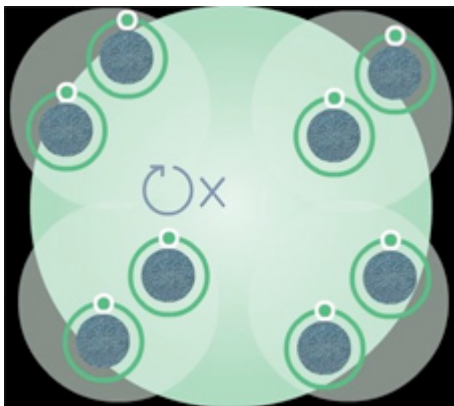


Figure 2a. Close-up of Graphical Interface



Figure 2b. Foot pedals.

The animated graphical interface (Figure 2a) is projected from a standard VGA or SVGA video projector onto a floor-based screen measuring 84cm x 119cm. Each of the eight green circles represents a channel which can store and play back a loop. When a loop has been recorded, the blue area inside the circle shows a representation of its waveform to help in differentiating visually between channels. The small green/white circles orbiting around the outside are animated to show playback and recording, with one complete orbit representing one cycle of a loop.

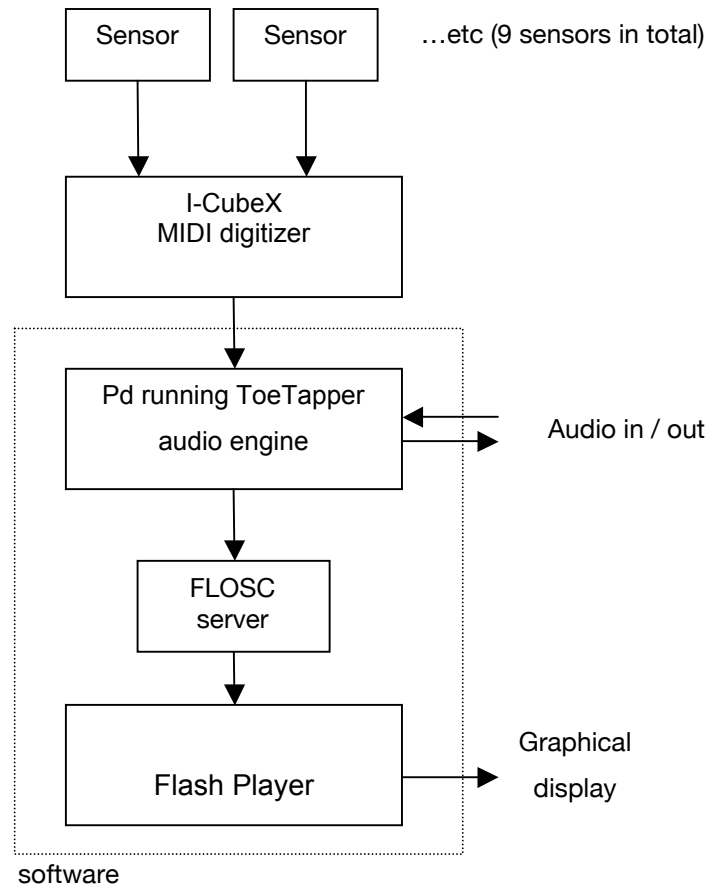


Figure 3: ToeTapper System Architecture

ToeTapper uses a combination of software environments (Figure 3). Reading of MIDI data from the sensors and recording/playback of loops is controlled by a set of “patches” written in Pure Data (<http://www.pure-data.info>), also known as “Pd”, a visual programming environment popular for creating interactive audio-visual applications. The graphical user interface (GUI) was written using Macromedia Flash MX, and so Flash Player runs alongside Pd to control graphical output. The FLOSC program (Chun, 2002) is a small server process written in Java which allows communication between Pd and Flash.

All of the software required to run ToeTapper is free and cross platform, and the complete system has been tested successfully without modification of code on three operating systems: Mac OS X, Windows XP and RedHat Linux. The system was mostly developed using a Macintosh G4 running OS X, with some work also done on Windows XP.

## User Evaluations

At the time of writing (January 2005) there have been two sets of user evaluations for the ToeTapper system: the first during August and September 2004 at the University of Dundee, with a variety of musicians and non-musicians taking part. A further set of evaluations took place in November and December 2004 at a centre for adults with physical disabilities. The second evaluation was intended to follow up comments made during the initial testing, in which participants suggested that ToeTapper might be of specific interest to this user group.

## First Group

Most of the testing for the first group involved each participant playing on the system solo, although there were also two group sessions. In all, 13 people tested the system, of whom 9 considered themselves musicians: 3 guitarists, 2 singers, 2 computer musicians, 1 drummer and 1 pianist. (In fact, everyone who tested the system had at least some interest in music, and a couple of the “non-musicians” have guitars stashed away in cupboards which they never play.) A microphone, an electric guitar, a MIDI keyboard and some small percussion instruments were provided for use in the sessions (Figure 1).

Evaluations took the form of an introductory demonstration, followed by participants playing with the system for as long as they wished (this turned out to be 10-60 mins). This was then followed by a semi-structured interview.

All of the participants managed to produce a loop of some sort; quite a few were of a high quality (including some of the non-musicians’ loops). The recipe for success seemed to be to engage with the sound and react to it. Most found the display easy to understand after the short demonstration, and seemed well able to engage with the system as they played: there didn’t need to be a shift or a break in attention as a part was played and then recorded.

Lack of space precludes detailed analysis of user feedback, but briefly some usability issues surfaced, mainly related to behaviour of pedals, representation or layout of loops, and timing issues. Opinion was divided as to the best application of ToeTapper, but majority opinion held it to be a compositional sketch tool: something used to jot down ideas for elaboration in other, more complex software. Four participants thought that it could be used as a performance tool.

## Second Group

The second set of evaluations took place at the Mackinnon Centre in Broughty Ferry, around 4 miles East of the City of Dundee. As well as being a respite care unit, the centre also includes a Skills Centre for adults with physical disabilities or progressive illness. Amongst the many activities provided by the centre’s Skills Officers are singing groups, keyboards and guitar tuition, and computer composition of music.

There is a wide range of talent and ambition amongst the clients who took part in testing: some produce original music of a standard sufficient for commercial release while others are happy to sing along to a CD or play melodies on a keyboard. All of the participants are regularly involved in making music at some level. ToeTapper was taken along for them to use during their scheduled weekly music sessions, to see whether it would benefit them in this. The system was installed on the centre’s Windows PC with their own video projector connected. The digitizer and sensors were taken along and connected to the PC with a set-up similar to Figure 1.

Unlike the first phase all evaluations were conducted in groups, since they took place as part of existing scheduled music groups. Four groups of between 3 and 5 people had joint sessions, so most of the resulting pieces were collaborations.

Many of the participants have mobility problems which made it difficult or impossible to operate controls on the floor, so in most cases the demonstrator operated the interface while the participants played or sang sitting down. In several instances participants were able to operate a repositioned Record switch, which gave them more control over the process. Again a variety of sound sources were used, including a keyboard, a synthesizer, some drums and a xylophone.

Musically, these sessions worked as well as those in the first phase of testing. The results tended to sound fuller (being group efforts, there was more impetus to fill all the channels), which on several occasions worked really well. There was distinctly less attention paid to the interface this time, however, and – inevitably – less control over the loops from the participants. Questioned afterwards, many of them said that the system had enabled them to do things they wouldn’t

ordinarily have done, but it was generally thought that the interface would have been better (for this user group) if it had allowed hand controls.

## Conclusions

Generally the evaluations were a valuable exercise in evaluating the system, and produced a useful check-list of (minor) alterations to the user interface. The simplicity of the graphical interface was seen by everyone to be a strength.

Some of the users with disabilities suggested using the controls with hands rather than feet, and it would be interesting to explore ways of making the interface easy to reconfigure in this and other ways. Making the controls wireless would help.

Although the system hadn't originally been conceived for collaborative use, it clearly works well as such and it may be worth considering how the design could be improved to encourage this – e.g. to encourage participants taking responsibility for one or two parts each while sitting around the circular display, similar to the Jam-O-Drum system (Bla & Perkis, 2000).

## Future work

We are currently developing a low-cost portable computer with a wireless sensor interface and running the free/open source Linux operating system, to allow ToeTapper to be taken "on the road" and so provide access to a wider range of users.

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