DJ SCRATCHING PERFORMANCE TECHNIQUES: ANALYSIS AND SYNTHESIS

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ABSTRACT

Scratching is a popular way of making music, turning the DJ into a musician. Normally scratching is done using a vinyl record, a turntable and a mixer. Vinyl manipulation is built up by a number of specialized techniques that have been analysed in a previous study. The present study has two main objectives. First is to better understand and model turntable scratching as performed by DJs. Second is to design a gesture controller for physical sound models, i.e. models of friction sounds. We attached sensors to a DJ equipment set-up. Then a DJ was asked to perform typical scratch gestures both isolated and in a musical context, i.e. as in a real performance. He also was asked to play with different emotions: sad, angry, happy and fearful. A model of the techniques used by the DJ was built based on the analysis of the collected data. The implementation of the model has been done in `pd`. The Radio Baton, with specially adapted gesture controllers, has been used for controlling the model. The system has been played by professional DJs in concerts.

1. INTRODUCTION

Music performed with the turntable and mixer, scratching, has become surprisingly popular, both among the musicians and the audience. Surprisingly of several reasons: Not many would guess that vinyl records would get a second chance after CDs arrived, and as instruments turntables are big and clumsy with a lot of necessary equipment (records, pick-ups, slipmats, audio mixers and steady tables to put it on). Not least, the sound of scratching is incomparable to that of any other instrument, as it lacks both explicit melodic or rhythmical qualities, but rather combines the two into a fast, fragmentary sounding instrument. This does not have to be a disadvantage, but to some it may sound too unfamiliar.

Most of what is played in scratching can be traced down to basic movements, as DJs control two parameters: 1) moving the record forward and backward and 2) cutting the sound on and off with the crossfader.

It seems to be a simple task to model scratching and replace the turntable, with all its drawbacks, but attempts from the producers of DJ equipment has not been all that successful. We need to know more about how scratching works both musically and as an instrument. Also it is interesting to look further than manipulating only the recorded sounds, and extend the scratch music vocabulary to controlling physics-based sound models.

1.1. Background

In earlier studies of scratching, it was found that DJs build their music around a set of learned gestural patterns, and these patterns are recognized as different “techniques”. From the growing number of techniques, there are about 50 that can be called fundamental or even necessary to know as a scratch DJ [1]. Still, the techniques are seldom performed in a simple one-after-the-other fashion, but rather intertwined and in complex structures [2]. This is probably varying in degree from one DJ to another, but not yet investigated.

1.2. Method and set-up

A professional DJ from Sweden, *DJ 1210 Jazz*[1], volunteered for the experiment and was the only subject. DJ 1210 Jazz has no formal musical training, but has for almost 15 years been considered to be among the best turntablists in Sweden and Europe.

In the recording sessions eight performances were executed, all of which without a backing drum track. Since DJ 1210 Jazz is an experienced performer, the lack of backing track was not considered a restrictive or unnatural condition even though scratching often is performed to a looped beat.

The DJ was asked to play in a normal way, as he would do in an ordinary improvisation. The performances from that session were by all means representative examples of improvised solo scratching with a clearly identifiable rhythmic structure. All sounds were originated from the popular “ahhh” sound from “Change the beat” [3]. This sampled part is found on the DJ 1210 Jazz [4] record we used. The recordings were done at KTH during 2001, and the equipment used for the experiment is summarized in Table 1.

Table 1: Equipment used for the experiment.

Equipment	**Description**	
Turntable	Technics SL-1210 Mk2 with felt slipmat	
Cartridge	Shure M44-7	
DJ-mixer	Vestax PMC-06 Pro	
Faders	Vestax PMC-05 Pro	
Record	DJ 1210 Jazz, “Book of Five Scratches: Book 2.” [4]	
Potentiometer	Bourns 3856A-282-103A 10K	
DAT-recorder	Teac RD-200T Multichannel	Ch.1, 20 kHz, Pot.meter
		Ch.2, 10 kHz, Crossfader
		Ch.3, 10 kHz, Audio
Wave analysis software	Soundswell Signal Workstation [5]	
	Wavesurfer [6]	

The analysis was done on the basis of three signals; the crossfader, the record movement and a waveform of the recorded

[1] His real name is Alexander Danielsson.

sound. The right audio channel was output to a multichannel DAT recorder, while the left channel was output to a headphone mixer so the DJ could hear himself.

A potentiometer was used to track the vinyl movement, and it was mounted to the vinyl with the help of a stand. No effect could be noticed in the performance and friction on the vinyl when it was attached, and the DJ felt comfortable with the set-up. The output was recorded by the DAT.

Two cables connected from the mixer's circuit board to the DAT tracked the crossfader slider movement. The crossfader run is 45 mm, but the crucial part from silence to full volume (the so-called cut-in point), spans only a distance of 2-3 millimeters, a few millimeters away from the (right) end of the slider run. Positioned to the right, the crossfader completely muted all sound, and it let through all sound when moved a few millimeters (to the left).

Only the right channel of the stereo sound output signal was recorded to the DAT, but that was sufficient for evaluating the record movement output against the sound output. The original sound from the record had no significant stereo effects, and both right and left channel appear similar.

2. ANALYSIS

Considering the analysis from earlier experiments [2], a scratch simulator must include a volume on/off function, as almost none of the scratches are performed with the volume constantly on. There is no need to be able to control bigger scratch areas than 360° while 180° should be easily controlled.

From the analysis and data a model of scratching was built. The readings of the potentiometer and the crossfader recorded were used to control an audio file. By first using the output from the potentiometer to change the sample-rate of the audio file that was played back, and then using the output from the crossfader circuit board to change the playback volume level, we successfully resynthesized the few techniques we tested on. Three techniques involved record movement only; *baby*, *tear* and *scribble*, while six techniques, *chop*, *roll-tear*, *crab*, *flare*, *uzi*, *chirps* and *twiddle*, also involved crossfader movement.

2.1. Models of scratch techniques

Analysis of the data relative to one *baby scratch* cycle shows that the DJ moves the record forward and backward to its starting position in about 260 ms. Knowing the sounds' position on the record, it was possible to calculate the distance travelled by the record and the velocity of the record itself. The velocity of this movement has the typical shape of target approaching tasks [7]. In the DJ pulling action, the velocity reaches its maximum when the record has travelled a little over half of the final distance, then velocity decreases to 0 value when the DJ starts to push the record forward. During the pushing action, the record increases in velocity in a shorter time than in the pulling phase. It thus reaches maximum velocity before having travelled through half the distance covered in the pushing action.

The same observations and measurements can be done for the other scratching techniques taken in consideration. *Chop*, *crab*, *flare*, *chirps* and *twiddle* scratch models use *baby* scratch as the basic record movement as do most scratches where the crossfader is the main feature. Still the record movement varies in each case from the simpler *baby*.

To simulate the record playing, the sample to scratch should be looped. When the sample is running in a loop, a mouse may be used for dragging the "record" forward and backward. It will not feel much like scratching for real, however, as you have to press the mouse button on the right place on the screen and move the mouse simultaneously. Even if the ability to do this smoothly and efficiently can be trained, there are better devices and sensors for this purpose.

3. SYNTHESIS

Results from measurements and analyses were used for the design of a model of scratching. `Pd` [8] was chosen as software environment for this model. Recorded sounds can be controlled by the scratch software in the same manner as by turntables, but the model can also control physics-based sound models of i.e. friction sounds [9]. The `pd` patch, *Skipproof*, is open and customizable to be controlled by various types of input devices. We have tested the patch with both recorded sounds and physics-based models, and we have controlled the model by use of computer mice, keyboards, MIDI devices, the Radio Baton[2], and various sensors connected to a Pico AD converter[3].

3.1. Skipproof – a pd patch

Skipproof[4] has three main functions. It is an interface for manipulating the playback tempo of a sound-file by using a computer input device, and it is an interface for triggering single scratching techniques. With these two functionalities, Skipproof acts as both a virtual turntable and a scratch sampler/synthesizer. In addition, the output volume can be controlled manually or by the modelled scratch techniques. With this third functionality, Skipproof also simulates the scratch audio mixer.

Skipproof uses GrIPD [10], a GUI front-end program for `pd`. `Pd` processes all sounds, and GrIPD offers control over the different options programmed in `pd`.

The sounds manipulated in Skipproof are 44.1 kHz or 88.2 kHz, 16 bit mono wave-files, but other formats can easily be supported. Sounds, or 'samples' in analogy to DJ-terms, are meant to be 1.6 s long in order to imitate a real skip-proof record, yet there is no restriction to the length.

Apart from direct manual "scratch control" of a sound-file, it can be accessed via recorded scratch movements. These recordings originate from the measurements analysed in the earlier reported experiments.

Skipproof can be controlled by different sensors and hardware, and is easy to adjust to new input devices. Sensors, MIDI input and computer inputs (keyboard and mouse) are used both to trigger the scratch models and to manipulate the virtual turntable and audio mixer, and their parameters. The intention of Skipproof is that it should be controlled by hand gestures, and that the graphical

[2]The Radio Baton is a controller for musical performances that tracks the motion of a sender in a 3-dimensional space. It is developed by Max Mathews.

[3]Pico Technology. The ADC-11/10 multi channel data acquisition unit, http://www.picotech.com/data-acquisition.html

[4]The name Skipproof is taken from a feature found on DJ-tools records called a skip-proof section, where a sound is exactly one rotation long and repeated for a couple of minutes. If the needle should happen to skip during a performance, chances are quite good that it will land on the same spot on the sound, but in a different groove. The audience will probably not register this jump.

interface is just for visual feedback. Computer mouse is not the controller of choice, but is a tool most users have, so we did not want to exclude it.

3.1.1. Implementation

In the following, the pd patch will be commented, explaining briefly how Skipproof is designed.

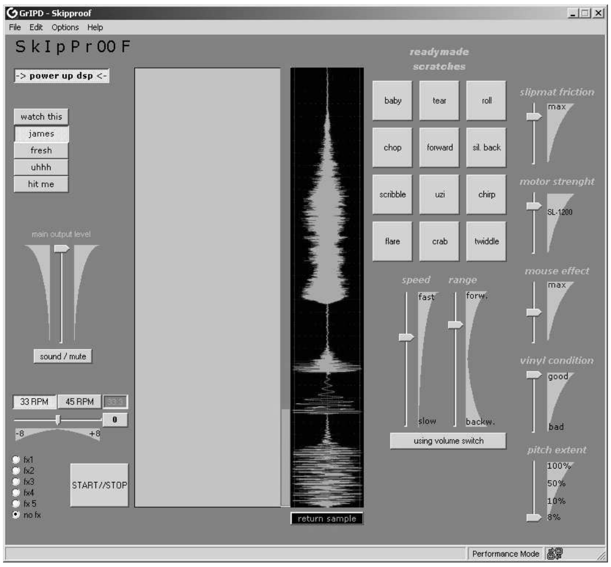

Figure 1: Graphical interface for Pure Data, GrIPD with turntable and audio mixer controls.

Figure 1 shows the performance window in Skipproof. One main focus designing the graphical interface was to some extent copy the functionalities of a turntable and a mixer. There are also a number of other buttons and sliders not found on the standard hardware, enabling the DJ to change parameters of, amongst others, motor strength.

The large light grey rectangle in Figure 1 is the part that registers mouse action (when left mouse button is held down). The meter next to the grey area displays the sound progression in relation to the wave plot. Around this 'vinyl record part' all the standard turntable buttons are collected; start/stop, two buttons for toggling 33 and 45 RPM, and a pitch adjustment slider. On a turntable there is also a power switch that lets the platter gradually stop rotating by its own low friction. When stopping the turntable with the stop-button it is the motor that forcefully breaks the rotation speed. The power-switch is sometimes used to produce a slow stop, but is omitted as a controller here.

Only two controllers are chosen from the audio mixer's many possibilities. The up-fader is replaced by a logarithmic master-volume slider. Normally the crossfader is far more utilized than the up-fader, but a slider is not an advantageous way to control volume when the mouse is occupied with record speed. Under the slider is a push-button which shuts out the sound (or turns on the sound) when activated. This button mixes the functions of the line/phono switch and the crossfader and can be assigned to keys or other inputs.

Under the heading "readymade scratches" (up right in Figure 1) there are several buttons for triggering the recorded techniques. Below, two sliders define the speed and the depth these techniques will have. The speed range is a bit broader than what is normally performed. The depth slider goes from long backward movements to long forward movements, also making exaggerated performances possible.

Both horizontal (x) and vertical (y) mouse activity is measured. Vertical mouse movement values are used for adjusting the playback sample rate. Horizontal movement can be used for several purposes, i.e. different audio effects, or simulating the hand placement on the vinyl as the effective record movement vary depending on where the record is held.

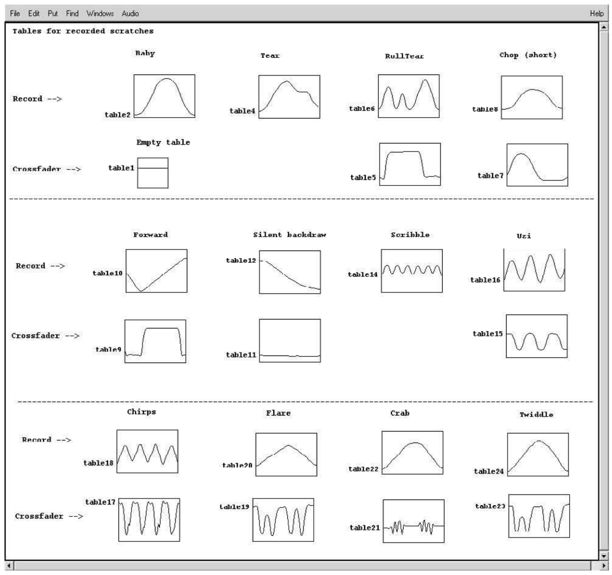

Figure 2: Pd tables: The recordings of 12 scratch techniques in tables. The upper row in each section shows record movement, and the lower row shows crossfader movement.

All the recorded scratches used for synthesizing single techniques are collected in "pd tables" for simplicity, see Figure 2. The empty "table1" is for techniques where the crossfader is not utilized, *baby*, *tear* and *scribble*. In this way all techniques can follow the same procedure in the model.

Signals from crossfader and record movements are low-pass filtered at 30-50 Hz before implemented in Skipproof. Each of the techniques is picked out from a series of repeatedly performed single techniques, and so represent an idealized model. Apart from those techniques that consists of many small movements on the record, as in *chirps* and *scribble*, only one stroke forward and backward is included for all scratches. The scratches vary in length.

To simulate the wearing of the vinyl, as explained in an earlier experiment [2], a simple noise model was implemented. Following several notions, it generates low-level white noise, narrow-band noise and vinyl defects as cracks and hisses. All the noise signals are recorded to a 1.6 s long table, so the vinyl defects always occur at the same spot on the record when it is looped and responds accordingly to scratching.

Sounds in Skipproof are sampled sounds. The user can add her own choice of sounds to be scratched. Skipproof can also be applied to the control of sound models.

3.1.2. Controllers

In this section some alternatives to standard MIDI and computer input controllers are presented. An analogue-digital converter from Pico sends the signals from the control devices to the computer. The voltage output is then read in `pd`, controlling the described parameters.

The crossfader on modern scratch mixers is becoming easier and easier to move; some models have friction-free faders. Still it takes a lot of training to accurately jump the fader over the critical cut-in point. To make it easier to accomplish fast and precise clicks, a light sensor replaces the crossfader.

The Radio Baton was used as gestural controller for Skipproof. The drumstick-like batons were substituted by a newly developed radio sender that fits the fingertips using a thimble. This new radio sender allows users' interaction based on hand gestures (see Figure 3), as the three-dimensional position of a finger in the volume over the antennae is detected.

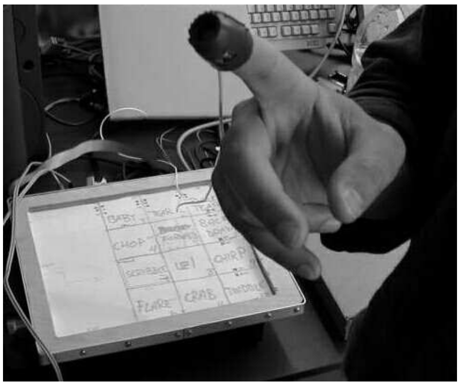

Figure 3: Thimble gestural controller for the Radio Baton and the antennae with sections drawn in.

The Radio Baton's receiving antennae is divided into one area for scratching and 12 smaller sectors, each sector hosting a prerecorded scratch technique (see Figure 3). Each modelled technique will be played according to the movements towards the antennae within the constraints of a sector. A fast dive with the hand down to the surface will produce a fast scratch performed with long record movements (high pitch), while a slow diving gesture in the air will achieve the opposite effect, a scratch performed slowly over a small area.

While scratching on a turntable only allows movement in the plane, the Radio Baton offers a third dimension, height, for controlling the instrument. So far we have tried to control the physical parameters, i.e. friction and movement amplitude, and also added functionalities not possible with a turntable, i.e. digital audio effects. Even the position on the "vinyl" in the horizontal axis can be mapped to new parameters.

4. CONCLUSIONS

Skipproof have been tested a few times, both by professionals and novices. Two times it have been played in concert situations before an audience[5]. Professional DJs tend to compare it with their usual equipment immediately and find problems in accuracy and controllability. It can be explained in different ways, but the Radio Baton has some clear disadvantages, among other factors the radio sender must be wired to the antennae, and the detectable area is more spherical than cubical. This makes the Radio Baton and Skipproof somewhat hard to play, yet both professional and novice users find it not only amusing but useful in a musical situation.

Especially the DJs like the extra dimensions the Radio Baton provides. All seem to have different ideas how to use them. It will require some training to be able to play Skipproof, which is the case for most musical instruments.

To simulate every aspect of the turntable, the vinyl, the needle and aspects like wearing, will probably turn out to be the only suitable option for making an acceptable replacement for today's instrument set-up. Scratching with physics-based sound models has only been tried once in concert, but the DJ seemed intrigued by the possibilities. An approach built on physics-based modelling technique seems therefore appropriate and worth to experiment further with in the future [11].

Arguably, the most characteristic quality in scratching is the big range of recognizable and universally agreed-upon playing techniques. Future research can reveal interesting issues regarding these. Also, technology aiming to replace the turntable should take into consideration the role and practises of scratch techniques. The techniques and characteristics of the hand movements associated with different types of scratches will be examined in future investigations.

[5]Online video clip from DJ 1210 Jazz' performance with Skipproof: http://amarone.sci.univr.it/pub/bscw.cgi/d16000/RadioBaton-scratch

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