DiskPlay: In-Track Navigation on Turntables

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ABSTRACT
Although digital media playback and storage have several advantages, many DJs still prefer using vinyl records on turntables due to their direct manipulation and haptic qualities. The physical structure of a traditional vinyl record provides important cues for in-track navigation, such as track length or location of loud and soft passages. Digital vinyl systems use a timecode record to combine the advantages of digital playback with the handling DJs are used to. These records contain a special audio signal that is processed by a computer and mapped to information such as playback speed, direction, and absolute position in a track. However, due to their generic nature, timecode records cannot provide visual information to navigate inside individual tracks. Using top-projection, DiskPlay augments a white timecode record with individual visual features of the medium, such as cue points or track start and end. In our observational study with four professional DJs, participants valued the co-location of visual feedback with the control vinyl on the turntable.

Author Keywords
Digital vinyl system, DJ, turntable, music, visualization, tangible interface, augmented reality

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: User Interfaces

General Terms
Design; Experimentation.

INTRODUCTION
Although a purely analog technology, turntables have survived long into the digital era, especially because they are an irreplaceable tool for musical expression for many DJs. DJ terminology and tasks have been elaborately explained in [2]. Our system focuses on beatmixing DJs. These DJs use two turntables and an audio mixing console. The DJ plays a series of tracks, called a *set* or *mix*, thus creating a single longer, seamless new track. She starts by playing a record on the first turntable. While this *outgoing* track is playing, she puts another track on the second turntable and, using headphones, matches the tempo of this second, *incoming* track to the one of the first, but without playing it to the audience yet. A felt slipmat between platter and record lets her manipulate the record independently of the rotating platter beneath (fig. 1). To synchronize the speed, the DJ will first search for the first beat on the incoming track and, without stopping the turntable, halt the record with her fingers. She then waits until the according beat of the outgoing track is reached and releases the vinyl such that the tracks are now playing in parallel. By accelerating or slowing down the platter, the DJ keeps both tracks in sync while adjusting the playback speed with the turntable's pitch fader until both tracks play at the same tempo. At some point, usually close to the end of the outgoing track, the DJ will mix the incoming track into the outgoing one, such that the audience cannot determine where the outgoing track ends and the incoming one starts. After this transition, she switches the track on the first turntable to a new incoming track, and the process starts again, with the two turntables switching roles. This way, "each song will be mixed into the next to give the appearance of a seamless stream of music" [2].

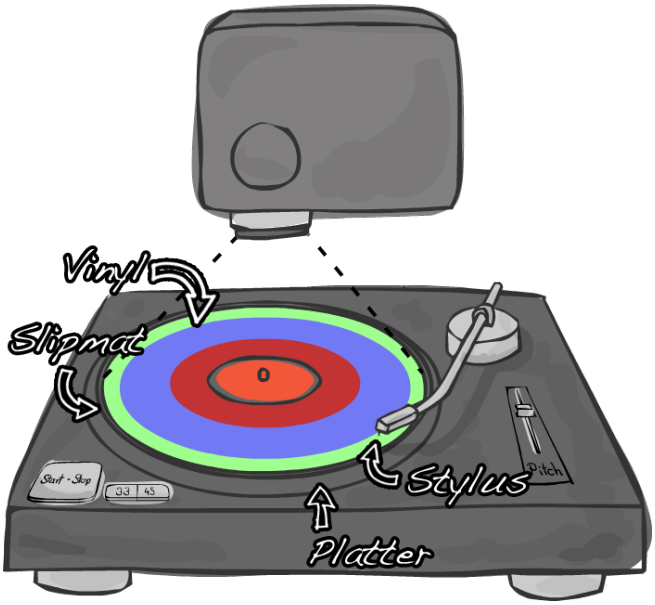

Figure 1. Using top projection, DiskPlay augments a white timecode vinyl disc with information about the structure of the current track, such as its starting point, length, and cue points.

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CHI '12, May 5–10, 2012, Austin, TX, USA.
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FROM ANALOG TO DIGITAL

The physical grooves on a classical vinyl record provide several cues about the audio track they contain. They indicate where a track starts and ends, as the grooves in the lead-in and lead-out areas (before and after the track) are spaced much more loosely (fig. 2(a)). Additionally, grooves in louder parts of the track are larger and need more spacing than those in quiet parts [12]. These features can be used to visually estimate the track's structure (fig. 2(b)).

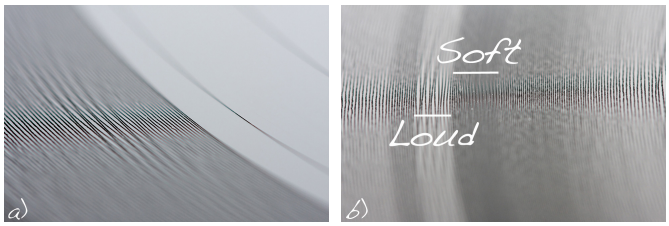

Figure 2. Physical structure of a vinyl record. (a) The lead-out at the inner end of the record looks different from the grooves inside the track. (b) Groove spacing varies depending on the volume of the audio signal.

Since today's music production workflows are largely digital and digital music distribution channels are fast and cheap, the market for vinyl records is small. While you can easily carry your entire music library on a laptop, the physical records a DJ needs for a set become heavy and cumbersome quickly [6], and wear and tear of a record that is played extensively limits its lifespan [6]. Despite these disadvantages, the direct manipulation of the record and the haptics of the turntable make them irreplaceable performance tools for many DJs [8]. Some CD players, such as the Numark CDX[1], are equipped with a turntable-like control interface to mimic its handling. However, the lack of a tonearm requires new in-track navigation techniques, and the physical structure on the control vinyl is unrelated to the track loaded.

Digital vinyl systems (DVS) like Serato's Scratch Live[2] or Native Instruments' Traktor Scratch[3] use a special vinyl record to control playback of the audio player software, and provide DJs with the haptic feedback they are accustomed to. Instead of a music track, the record contains a special timecode audio signal. This timecode is processed by a computer and translated into information such as playback speed, direction, and absolute playback position. This lets DJs build on their perfected manual skills with the usual equipment, while providing the advantages of digital media storage and playback, including independent control of pitch and tempo. However, since timecode records are generic, they do not show the visual structure of an individual song anymore. The length of the timecode does not match the length of the track loaded in the software, nor does the physical structure of the grooves relate to the auditory structure of the track.

[1] www.numark.com/cdx
[2] serato.com/scratchlive
[3] www.native-instruments.com/traktorscratch

RELATED WORK

Numerous projects in research and industry have aimed to enhance turntable-based interaction in the DJ context.

TIMBAP [10] focuses on turntable-based navigation of a media library. Using a top-mounted projector, the artworks of each piece are displayed on the record, and the DJ can navigate through his music library by either seeking linearly (i.e., spinning the record) or searching tracks by a tag cloud interface that is manipulated by displacing the stylus on the record. However, this system is used only for track selection. It does not support in-track navigation and does not bring back the individuality of the medium.

An artistic installation using timecode records is Vinyl+ [5]: an image of colored bubbles and dots is projected onto the record. When the stylus passes a dot, a specific sound sample and a visual effect are triggered. Vinyl+ connects visual and auditory channels, but does not support navigation inside existing tracks, making it more of a musical instrument.

D'Groove [3] is a force feedback-enabled turntable to explore new ways of manipulating music. The turntable has distinct marks for the four beats of a bar, and its rotation speed is coupled to the song tempo such that the beat marks form a spatial landmark while beatmatching two songs. A motorized slider indicates the progression of the track over time and allows to control the playback position. Among the force feedback modulations implemented are a *bump-for-beats* mode providing a physical sensation of each beat, and a *resistance* mode that makes it harder to move the record "when it is playing an area of high-energy music". The system conveys additional track information over the haptic channel, which supports local in-track navigation. However, D'Groove introduces new turntable hardware with new interaction techniques, and it does not provide an at-a-glance overview of the track structure.

The Attigo TT[4] is a touch-screen based visual turntable, designed to easily work with digital audio content. It allows DJs to directly work on the waveform, resulting in fine-grained control. But as with the multi-touch enabled DJ environment presented in [9], they introduce new interaction techniques, and the lack of haptic feedback prevents DJs from calling on their familiar and perfected techniques.

Figure 3. Traktor Scratch Pro user interface. The left track is close to the end, indicated by the waveform overview flashing red.

[4] www.attigo.co.uk/

THE DISKPLAY SYSTEM

The focus of DiskPlay is to enhance the DVS setup such that the information available on a classic vinyl becomes visible again. Current DVS implementations separate visualization (on the computer) and control (on the turntable). Most vinyl emulation software implements some kind of visual notification alert to inform of the upcoming end of a track, e.g., by some flashing UI element (fig. 3). Nevertheless, this requires the DJ to repeatedly glimpse at the computer display while he is mainly working with the turntable. DiskPlay integrates visualization and control by augmenting the timecode record with important information (fig. 4). First, we visualize track

Figure 4. DiskPlay displaying a track. (a) Remaining playback area (blue). (b) Part already played as progress indicator (green). (c) Unused timecode part (red). (d) Cue points (yellow dots).

length. When loading a track onto a virtual deck in the software, the part of the timecode vinyl that covers the playback length of the track is colored blue while the remaining, unused part is colored red. This shows where the track begins and ends. As playback progresses, the part of the track that has already been played is colored green to indicate the progression over time (fig. 4). To quickly jump to specific points in a track or to loop certain samples, DJs use stickers that they place as marks on the record. These *cue points* are displayed on the record as yellow dots. To simplify navigating to a cue point, a concentric black circle is drawn with the dot's radial distance to the center as radius. This helps place the stylus in the correct groove while the record is spinning.

To study our interaction design, we built a prototype around a turntable with a white timecode record and a projector above it (fig. 5). We extended the open-source DJ software Mixxx[5] with an on-record display. Mixxx [1] is a software framework to explore new interaction techniques with regard to DJ applications. Its flexible software design makes it easy to integrate modules for different input and output modalities. The user interface of Mixxx is common among popular DVS software, providing our users with a known environment. One of the turntables was equipped with DiskPlay, the other one with the current standard tool set. Tasks of mixing towards and away from the DiskPlay turntable stressed different aspects of the visualization. While actively mixing with DiskPlay, track start and cue points are more important, whereas the playback position and track length are needed while handling the other turntable.

[5]www.mixxx.org

EVALUATION

Since DiskPlay is a tool to support artistic expression, we conducted an observational study with four professional DJs referred to as DJ1–DJ4 to gather qualitative feedback. All DJs had between 5 and 20 (average 12) years of experience, and between 0.5 and 5 (average 2.5) years of experience with DVS. Our setup consisted of two Technics SL–1200MK5 series turntables (one equipped with DiskPlay) and a standard Gemini BPM–1000 mixing console. After a brief explanation of the system and importing each DJ's personal music library into Mixxx, each participant mixed for 25 minutes with traditional timecode records as control condition. We then asked participants to take a short break, and enabled the DiskPlay visualization. Starting with the augmented turntable, the DJs continued mixing in the experimental condition for another 30 minutes. Participants were encouraged to think aloud and mention anything interesting or intriguing. After the mixing session, we asked participants about anything we had noticed, along with some general feedback questions about the systems. In the following, we present our observations and insights from those semi-structured interviews.

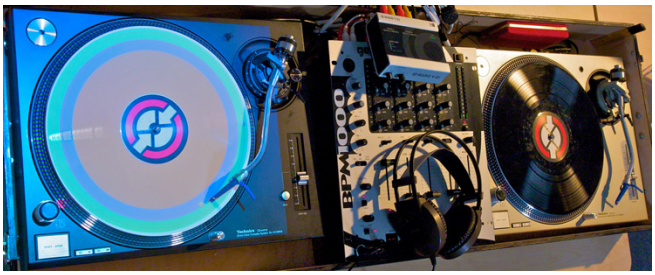

Figure 5. The DiskPlay test setup with the augmented turntable on the left and the traditional timecode vinyl on the right. The projector (not in the picture) is above the left turntable.

Without DiskPlay, all participants used the computer display to orient themselves in the track structure and to see how long a track still had to play. This changed with DiskPlay. DJ2 only used the computer to load the next track, then solely worked with the turntables and the mixer. DJ1 used the cue-point visualization for coarse in-track navigation, but then reverted back to the computer display. He explained that he could not hit the exact groove of the cue point and did not know if he had to spin the record one, two, or three times to reach the cue-point. DJ3 looked at the computer very often, with and without DiskPlay. When asked why, he explained *"I often look to the display, no matter if I want to gain information from it or not. It's a habit"*. The most important aspect, the visualization of start and end of a track, was very well received. As DJ1 stated, *"the most embarrassing thing that can happen to a DJ is that the song is over without him noticing it and therefore has no time to create a smooth transition by beatmatching"*. This happened to one of our participants during the accommodation phase of the test. To prevent such mistakes, DJ3 asked for a functionality that alerts him

of the upcoming end of the track *"something flashing would be nice"*. Three of our participants suggested adding an absolute time display onto the turntable, and two asked for a BPM indicator. All participants liked the simplicity and intuitiveness of the augmentation. DJ4, who was more into scratching than the other participants, mentioned the cue-point functionality as a good replacement for the labeling technique used by scratch DJs.

CHANGING THE SPECTATOR EXPERIENCE

One very interesting aspect was brought up by DJ1: *"Most people in the audience don't know what the DJ is actually doing during his performance. It would be nice if the visualization could give the people an understanding of the DJ's job"*. Electronic music performances in general struggle with the fact that the audience does not necessarily perceive a physical motion of the artist as correlated to a change in sound [4]. Especially the use of the laptop-turntable combination seems to be hard to understand for the audience. One of the participants mentioned that a spectator had once asked him if he was checking his email while playing a set. This lack of communication is crucial, because "watching the motions of the DJ during the performance can be almost as exciting as listening to the music being played" [2]. The Cubic Crossfader, a bluetooth enabled tangible control part of the ColorDex system [14], allows the DJ to move around and thereby supports interaction with the crowd.

Spectator experience can be classified along two axes [11] that describe how manipulation of a system in public and its effects both range from *hidden* to *amplified*. The activity in the DJ booth can be classified as *partially hidden*, as at least some of the manipulation is visible. With DiskPlay, this is leveraged to *visible* since it becomes easier to get a grip on what the DJ actually does. With an additional mirroring display, DiskPlay could become an integral part of the DJ's performance and its visual appeal, as with the Waves interface [7] for VJs.

CONCLUSION & FUTURE WORK

We presented DiskPlay, a system that augments a timecode vinyl with information that is visible on traditional records. In the process of digitalization, information that was once individual to a physical medium can be lost. Augmented reality allows to recreate and even extend this individual visual information on a generic control device. Although focussed on the specific setting of DJs, the presented approach can be generalized to other digitized interactive systems, e.g., video navigation or navigation of other cyclic data.

In the current implementation, the visualization mostly focuses on the needs of beatmixing DJs, but the integration of the waveform display would make the system interesting for scratch DJs as well, as it helps finding an exact beat in the track. With the integration of library browsing as presented in [10], this system could make it unnecessary to look at the computer display, allowing the DJ to completely focus on the turntables and her artistic performance. The last missing feature of classic vinyl, the visibility of the softer and louder parts of a record, can be visualized by different shades of color, helping to find, e.g., a specific break. Finally, we envision the display to be integrated into the turntable, building one robust unit. This could be achieved using a transparent platter, similar to the system presented in [13], or by integrating projection technology similarly to the the stylus illuminator.

Acknowledgements

We would like to thank Justus Lauten for his support during implementation and evaluation of this system and our test DJs for their time and participation in the evaluation. This work was funded in part by the German B-IT Foundation.

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