MIDI Keyboard Defined DJ Performance System

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ABSTRACT
This paper explores the use of the ubiquitous MIDI keyboard to control a DJ performance system. The prototype system uses a two octave keyboard with each octave controlling one audio track. Each audio track has four two-bar loops which play in synchronisation switchable by its respective octave's first four black keys. The top key of the keyboard toggles between frequency filter mode and time slicer mode. In frequency filter mode the white keys provide seven bands of latched frequency filtering. In time slicer mode the white keys plus black B flat key provide latched on/off control of eight time slices of the loop. The system was informally evaluated by nine subjects. The frequency filter mode combined with loop switching worked well with the MIDI keyboard interface. All subjects agreed that all tools had creative performance potential that could be developed by further practice.

Author Keywords
DJ, Electronic dance music, performance, exploration

CCS Concepts
• **Applied computing → Sound and music computing**; Performing arts; • **Human-centered computing →** *Interface design prototyping*;

1. INTRODUCTION
Electronic Dance Music (EDM) DJs characteristically blend and sonically manipulate two or more audio tracks to produce a seamless output of audio content. Traditional DJ systems typically feature two vinyl turntables and simplified audio mixing interface which enable the DJ to beat-match, cue and crossfade between sound sources and manipulate spectral characteristics of the sources [10]. DJ systems have evolved to also include virtual and hybrid solutions [8]. Hybrid systems enable DJs to use familiar traditional gestures [4]. Modern virtual systems extend the range of tools for sound source manipulation and musical expression.

The discipline of controllerism emerged in the mid-2000s. Moldover undertook bespoke hacking of MIDI keyboards to facilitate his EDM performance practice [7]. EDM DJs currently utilise a variety of commercial Music Production Centres/Workstations (e.g. Akai MPCs and Ableton Push).

Recent research has mainly focussed on extending the sonic manipulation capabilities of hybrid system by using traditional interaction gestures to control new types of parameters [1,3-5]. This paper takes an alternative approach, as adopted in the development of "ColorDex" [9]; which replaced the audio faders found on a DJ mixer with a hand held cube, and considers a simplification of the virtual DJ system interface.

This work replaces the hardware interfaces used by EDM DJs with the piano keys of a two octave MIDI keyboard controller and explores using this interface for time and frequency manipulation of EDM for use in loop-based DJ performance.

NIME'18, June 3-6, 2018, Blacksburg, Virginia, USA.

2. MOTIVATION
The motivation to use only the piano keys of a two octave MIDI controller as a virtual DJ system interface was:

1) Democratisation - MIDI controller keyboards are more widely available and affordable than hardware interfaces in commercial virtual DJ systems. Knobs, pads and faders which vary between controllers were excluded.
2) Playability - Inspired by Atlantic Records engineer Tom Dowd who enabled mix engineers to "play the faders like you could play a piano" by replacing the mixing console's large rotary knobs with slide-wire faders [2] providing an "affordance of music playability" [6].
3) Reductionism – To explore whether a simpler, easier and more accessible user interface can be created and to see if this has the potential to lead to new creative possibilities.

3. DJ/EDM TECHNIQUES
The following observations were made based on informal analysis of YouTube performance videos and the authors' experience.

DJs use predefined cue and loop markers to jump seamlessly between different sections of audio tracks. Faders are used to alter the level of "beat-matched" audio tracks to move seamlessly between tracks or to blend tracks. Peaking parametric filters are used to carve out specific frequencies. Low pass, high pass and band pass filters are also used to isolate specific frequencies or to sweep through frequencies. These three techniques are used sequentially, independently or in combination to realise a musical intention.

EDM production involves the creation and manipulation of repeating and varying loops at the micro and macro level. At the micro level, step sequencers are commonly used to create rhythmic and/or melodic patterns using oscillators and/or samples of pre-recorded audio material. At the macro level these patterns are sequenced and combined to create tracks either in a fixed sequence or dynamically performed in a live setting.

4. IMPLEMENTATION
The prototype interface was implemented using HTML5, JavaScript and the WebMIDI and WebAudio APIs (see Figure 1).

Each octave controlled one of two audio tracks as the ability to control at least two audio tracks simultaneously is a fundamental characteristic of any DJ system. Given more octaves this is extensible to control more tracks. The system ensured all audio elements were synchronised and looped continuously.

It appeared logical to use the inferred visual division afforded by the layout of the black keys on the interface. The first four black keys of each octave were used to switch between four different looped sections of the two audio tracks. This macro-level switching tool was inspired by the common practice of setting cue and loop markers. In contrast to commercial systems the switching of the two bar loops occurs at the current point in time of the loops.

The white keys were used to manipulate the audio tracks in either the time or frequency domain. The highest key (C3), shaded in grey in Figure 1, toggles between the two modes.

In frequency filter mode each octave's white keys provided control of a bank of filters. Low to high frequency was mapped from left to right to build on a user's prior understanding of how frequency is mapped across a keyboard octave. The bottom key controlled a low-pass filter (cut-off frequency of 100Hz), the top key controlled a high-pass filter (cut-off frequency of 6400Hz), the five remaining white keys controlled Constant Q Transform band-pass filters with -60dB of attenuation (centre frequencies of 200, 400, 800, 1600 and 3200Hz respectively). This allows the lower frequencies of one audio track to be blended with the higher frequencies of the other track or the snare drum from one track to be replaced by the snare drum from another. Despite the coarse resolution of frequency manipulation it seemed sufficiently effective.

In time slicer mode the white keys and the black B flat key in each octave perform a role inspired by the micro-level step sequencing found in Music Production Centres/Workstations. The currently active two bar loop of each audio track is sliced into eight beats, with each slice mapped to the keys from left to right. Pressing a key removes and skips the corresponding slice from the sequence. This allows polyrhythms to be explored by switching one loop to, for instance, three active steps whilst the other is playing four steps. It also allows the typical stutter of just playing one beat of a track repeatedly (although currently this can't be "sped up" as per the commonly employed EDM technique).

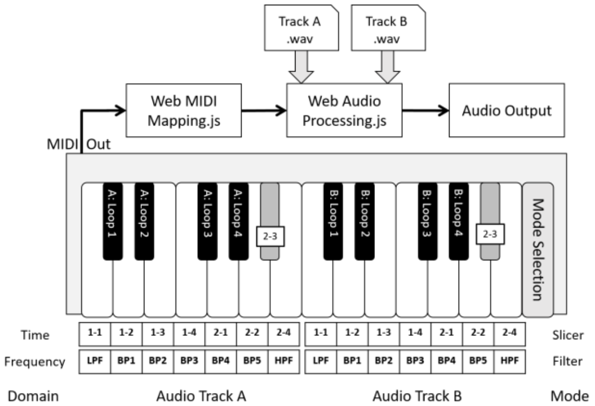

Figure 1: Overview of the Prototype System

Both latching and non-latching white key control was considered. Whilst the non-latching variation is more congruent with the keyboard paradigm it proved difficult to control all fourteen keys with two hands. Latching also enabled operation of the two modes simultaneously.

The authors initially resisted augmenting the hardware interface with a graphical user interface to avoid putting a barrier between the DJ and the audience. Difficulties of keeping mental track of the systems state meant that this was reconsidered and a simple graphical representation of the keyboard was displayed on a computer screen. Future work will consider ways of displaying piano key activity directly on the keyboard interface.

5. EVALUATION

The system was presented to eight Music Technology undergraduates and one technician with varying degrees of EDM DJing experience. The system was pre-loaded with two techno tracks. Three of the subjects evaluated the system alone and six in pairs. The informal evaluation was to gauge perception of the interface's efficacy and creative potential.

Overall the subjects found the system fun to use. Both an experienced and novice EDM DJ stated it was the best DJ system that they have ever used. Many of the subjects were observed nodding their heads in time with the music, smiling and verbally expressing their delight when intended sonic outcomes were realised.

Subjects quickly learnt the interface with little explanation. All subjects commented that the simplification of the user interface made the act of DJing more accessible. All subjects agreed that whilst the system was easy to use, they felt that over time they could explore each mode's nuances and people could become virtuoso performers.

All subjects agreed that the system had creative performance potential. Individual subjects were observed developing their technique and producing new output. Over time subject performances evolved to include multiple simultaneous key presses with some of the subjects using the side of their hands to perform chopping gestures which simultaneously activated/deactivated multiple keys. The authors observed subjects using the system in total for three hours and felt they were still hearing new variations of the system output at the end.

All subjects agreed that the system enabled them to modify the audio tracks in a way that was not possible or difficult to achieve with their current commercial DJ system.

The frequency filter mode was the most preferred mode overall. It was commented that the orientation of the keys of the keyboard in a one dimensional line in front of the user was better than the two dimensional grid format of pads adopted in Maschine and Akai MPCs and conformed to the common left to right visualisation of equalization (EQ) curves.

The time slicer mode was the least favoured mode overall and hardest to understand. Some subjects found it disconcerting that the change in audio output did not occur as soon as a key was pressed (slices would appear and disappear as the sequencer looped round).

In terms of collaboration potential, whilst we did not instruct the pairs of subjects to work together, two pairs were observed actively working together to interact with the keyboard, each taking control of a single octave and using verbal cues to direct a collaborative performance.

Many of the subjects commented that while the supporting graphical user interface was only required periodically it was still necessary to seek visual clarification of the system's state occasionally. Several subjects suggested augmenting the underside of each key with an LED and illuminating the active beat of the time slicer mode.

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