MIXME: A RECOMMENDATION SYSTEM FOR DJS

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1. INTRODUCTION

DJs represent an unique group of music information "retrievalists." During their performances, DJs are required to efficiently find candidate tracks and quickly choose one to play next in a set. Although different genres tend to have different mixing styles, such as quick cuts versus long mixes, beat-matching is undoubtedly a core and necessary skill. However, as mix lengths between tracks increase, so does the role that keys play in the listeners' experience as key clashes can easily interrupt musical enjoyment.

MixMe provides key-based recommendations using track selections and playback speed settings provided by the DJ, along with tempo and key information about tracks produced by the system. First, we analyze tempo of the tracks in a music collection, filtering out tracks that reside in unreachable tempo ranges based on the playback speed. After detecting key, we then calculate a normalized key, a non-integer representation of key for each track when played at a common, reference tempo. Through key normalization, we generate recommendations using relevant key relations when tracks are played at equal tempos. This type of recommendation will help DJs identify candidates that exhibit a key compatibility and aid in avoiding key clashes between tracks.

Commercial DJ software products such as Serato Scratch Live, Torq and Virtual DJ all provide speed adjustment controls and address key to varying degrees. MixMe takes a further step by identifying candidates that can be mixed on any DJ interface, including turntables.

2. THE MIXME SYSTEM

2.1 Phase I - Analysis

The architecture of the MixMe system is shown in Figure 1. MixMe performs two phases of analysis in order to provide key and tempo-based track recommendations. The first analysis phase (dashed in Figure 1) extracts key and tempo information from each track. For key detection, we use the

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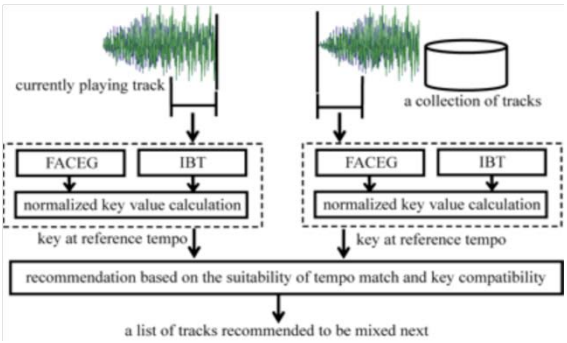

Figure 1. System diagram of MixMe.

Fuzzy Analysis Center of Effect Generator (FACEG) algorithm proposed in [1]. Tempo is determined using IBT described in [2]. DJs typically mix the trailing portion of a given track with the leading portion of the following track. We limit key and tempo feature extraction to these sections to decrease analysis time. The system uses this data to calculate a normalized key value for both track sections.

An arbitrary baseline value of 120 bpm serves as the reference tempo (T_{ref}) to normalize the key of each track. Through normalization, we are able to compare the keys of each track as if they were beat-matched and mixing at any tempo. First we determine the change in key (ΔK) when a track's tempo moves to 120 bpm from its original tempo:

$$\Delta K = 12(log_2 T_{ref} - log_2 T_{orig}), \quad (1)$$

where T_{orig} represents the original tempo of a track. We then calculate the normalized key (K_{norm}) as follows:

$$K_{norm} = (K_{orig} + \Delta K)\%12, \quad (2)$$

where K_{orig} is an integer between 0 and 11 representing one of the 12 possible original keys of the track.

2.2 Phase II – Real-time Recommendations

Recommendations occur while using MixMe during a DJ session. The user selects the current track and sets the speed adjustment in the range of -8% to +8% of the original tempo, the default range in most turntable devices. MixMe examines the other processed tracks in the music collection to generate recommendations based on tempo and key criteria. The system first determines whether each track in the collection can be tempo matched to the current track given its current speed adjustment and the candidate's available tempo adjustment range.

For tracks within tempo range, MixMe determines if the candidate exhibits a key compatibility with the current track. Specifically, we focus on relationships such as exact key matches, relative (C_{maj}/A_{min}), parallel (C_{maj}/C_{min}), dominant 5th ($C_{maj} \rightarrow G_{maj}$) and subdominant 4th ($C_{maj} \rightarrow F_{maj}$). Tracks are placed into one of seven categories based on their relations to the currently playing track. The first category contains tracks out of tempo range. The next five represent related keys: "Exact", "Relative" and "Parallel", "Perfect 5th" and "Perfect 4th" relations. The "Other" category contains tracks having none of the prior relations.

3. INITIAL FINDINGS

3.1 Data Collection

MixMe analyzed a collection of 252 tracks from 65 different artists in 9 genres and 34 sub-genres within electronic/dance music. Genres include House, Techno, Trance, Breaks, Electro, Hardcore, Drum and Bass, Downtempo, and Acapella. MixMe was implemented on a native iPad application written in C, C++ and Objective-C.

Manual key and tempo analysis helped assess the accuracy of FACEG and IBT. Manual key analysis entailed listening to each track and matching the track's key using a synthesizer. Manual tempo analysis was performed by using a digital metronome to monitor tempo.

3.2 Results

Accuracy of FACEG and IBT was determined by comparing the results of their analysis to the results obtained by manual analysis. Table 2 shows the number of tracks for which IBT arrived at the exact, half, double, or incorrect tempo as compared to manual analysis. Though IBT was only 37% accurate, tempo was half or double the actual tempo 61% of the time. These results are effectively 98% accurate for the purposes of our system. The main drawback was time to process tempo. Key finding and mp3 to wav conversion split 6% of the total processing time but tempo analysis encompassed the other 94%.

IBT Tempo Results Related to Manual Tempo Results		
Half	139	55%
Exact	93	37%
Double	15	6%
> 1bpm	5	2%
Totals	252	100%

Table 2. IBT Tempo Accuracy

FACEG Key Results Related to Manual Key Results		
Exact	50	10%
Parallel	69	14%
Relative	36	7%
4th / 5th	63	13%
Rel. + 4th/5th	44	9%
Par. + 4th/5th	44	9%
Par. + Rel.	31	6%
Double 4th/5th	14	3%
> 2 Steps	121	24%
No Key	30	6%
Total	502	100%

Table 3. FACEG Accuracy

Table 3 exhibits a comparison with FACEG to manual analysis. The table shows the number of occurrences where, when FACEG disagreed with the manual results, FACEG exhibited a key relation to the manual result. 10% of the keys determined by FACEG were the same as manual analysis. 33% of the FACEG keys had a one-step related distance to their manual counterpart via a relevant key. For example, a one-step distance occurred if FACEG found a track to be in the key of C_{maj} where manual analysis determined the track to be in C_{min} (parallel), A_{min} (relative), G_{maj}(5th) or F_{maj} (4th). 26% had a 2-step distance via a relevant key relation. These accounted for 70% of the results. 24% had a relation greater than 2 steps and 6% of the tracks were too challenging to manually identify key.

3.3 Observations

A limited data set yielded few results per relation. We assume a larger collection would yield more key relations. The recommendation interface appears in Figure 2 and will be on display during the late-breaking demo session.

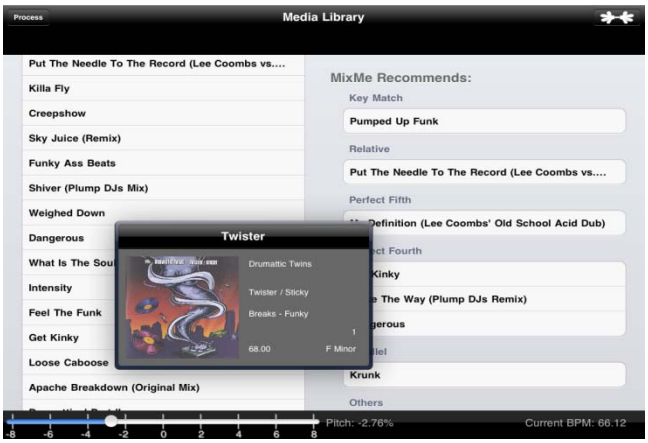

Figure 2. Recommendation Interface, with the current track (front), processed tracks (left), Recommendations (right), and speed adjustment information (below).

Preliminary results indicate that tracks with exact normalized key matches exhibit the highest compatibility and tend to mix well together. A short DJ mix (35:24) and accompanying video demonstrate the system and the various key relations and may be downloaded at: http://djfx.us/mp3/demos/DJ_FX_-_A_Perfect_Circle.zip

4. REFERENCES

[1] Chuan, C. H. and Chew, E., "Fuzzy Analysis in Pitch Class Determination for Polyphonic Audio Key Finding," *Proc. of the Int'l Conference on Music Information Retrieval*, pp. 296-303, London, 2005.

[2] Oliveira, J., Gouyon, F., Martins, L. and Reis, L., "IBT: Real-time Tempo and Beat Tracking System," *Int'l Conf. on Music Info. Retrieval,* Utrecht, 2010.