A New Analytical Method For The Musical Study of Electronica

Christopher Anderson, Arne Eigenfeldt

Simon Fraser University, Vancouver, BC (Canada)
canderso@sfu.ca, arne_e@sfu.ca

Abstract

In the late 20th and early 21st Centuries, the analysis of popular forms of electroacoustic music, such as electronic dance music (EDM), has widely been overlooked within electroacoustic music discourse. To further develop the growing field of electroacoustic music studies, new analytical methods are needed to help gain a better understanding of the theory and contexts of many newer forms of compositional areas, such as EDM. From the baroque gavotte to ballet, dance music has been historically analyzed for many years and since many other popular forms of traditional dance music – such as jazz or swing – have been the subject of complex rhythmic and timbral analysis. The study of EDM offers many new possible analytical approaches to the understanding of new sophisticated interactions between timbre and rhythm in popular forms of electroacoustic music.

The Generative Electronica Research Project (GERP), a collaborative research group within Simon Fraser University's (SFU) Metacreation Agent and Multi-Agent Systems (MAMAS) lab, have been working on a new method to analyze electronica that involves a combined human and machine-learning approach. In this paper, we propose to explore the similarities and differences between human and machine-based electronica analysis.

For the purposes of our research, we have chosen to analyze four popular sub-genres of EDM: Breakbeat, Drum and Bass, House and Dubstep. In our initial stage, we have analyzed at least 25 compositions within each genre, using a method of human analysis to quantify the commonalities and differences of electronica song forms and beat structures. Through this analysis method we are able to distinguish which timbral and rhythmic qualities are typical of each sub-genre as well as how the various song forms are constructed. By analyzing each isolated beat structure or loop, we are also able to quantify the defining timbral complexities of the many rhythmic structures within each song.

At the same time, we have created a MaxMSP patch that uses an FFT analysis to automatically extract beat patterns from song selections. Additionally, we have created a symbolic representation for both human transcription and machine transcriptions that allows us to compare both methods, and attempt to isolate unique identifiers between styles.

This paper focuses on identifying the basic musical structures that exist within these EDM genres; the next stage of our research will involve multi-agent systems using this data for generative purposes.

The new analytical methods from GERP can be used to further our research into the less explored areas of electronica analysis and will hopefully help broaden the scope of electroacoustic music research.

1. Introduction

Since the late 20th century the word Electronica has been associated with the categorizing and commercialization of many popular underground forms of electroacoustic music. With its origins in popular music and dance cultures, the label Electronic Dance Music, or EDM, is often used in place of Electronica to help differentiate between the many underground sub-genres and social music scenes. For the purposes of this paper, the discussion will be focused on explaining the first-step methodology and progress of a recent music analysis research project involving various EDM genres.

EDM is often researched in the context of cultural history or musicology. For example, the history surrounding underground music movements, such as rave culture, has been the subject of many papers and books, such as Simon Reynold's *Generation Ecstasy*. This paper however, will focus less on the musicological aspects of EDM, and instead on research involving music theory and analysis.

What makes EDM genres worth analyzing in the context of electroacoustic research? Many other popular forms of dance music such as jazz or swing have been the subjects of complex rhythmic, harmonic and timbral analysis. The study of EDM offers many new possible analytical approaches to the understanding of sophisticated interactions between timbre and rhythm in more mainstream forms of electroacoustic music. The roots of EDM stretch to many origins of electroacoustic music and often involve similar compositional techniques.

EDM and its sub-genres are sometimes less associated with academic electroacoustic music discourse, but there is still much to be discovered from this very large corpus of timbrally rich music. A few authors, such as Mark J. Butler, have written about EDM musical analysis. In *Unlocking the Groove,* Butler provides in-depth musical analysis and cultural perspectives of various EDM genres and producers. As Butler has demonstrated, the analysis of EDM can help expand on the knowledge base surrounding this large corpus of lesser-known genres of electroacoustic music.

2. Research

As part of Simon Fraser University's Metacreation agent & Multi-agent Systems research group, The Generative Electronica Research Project (GERP) is researching the compositional complexities of various genres of EDM. Such research will be used for creating new electroacoustic compositions with multi-agent generative systems for further research purposes. The group of composers, led by Dr. Arne Eigenfeldt of SFU's School of Contemporary Arts, and scientists, led by Dr. Philippe Pasquier of SFU's School of Interactive Art and Technology, are conducting a long-range study of EDM for research towards generating stylistically accurate EDM compositions. This research is conducted through the use of human informed machine learning. Over the next few years, we are looking to accurately reproduce various genres of EDM to a highly comparable level. To achieve this level of accuracy, we are relying on a specific method of electroacoustic music analysis.

For the initial stages of research, we have decided to analyze four popularly labeled sub-genres of EDM: Breakbeat or Breaks, Drum and Bass, Dubstep, and House. We have decided to quantify many common traits of these select few genres, but may expand to others as the research progresses.

From each genre, one hundred songs or tracks were selected. The selection of these genres or styles were based upon a number of factors:

1. They are produced for a non traditional dance-floor audience and display clear repetitive rhythmic beat patterns
2. The styles can be clearly defined based on commonalities and significantly different from one another
3. There is common instrumentation within each of the separate styles
4. They are less complex than some other styles of electroacoustic music

Individual songs or tracks were chosen to represent diverse production characteristics within the time-span between 1994 and 2010, with only four artists being represented twice. The tracks chosen contained many common formal and structural production traits that are observed to be typical of each style and period. They were also tonal, of a fixed pitch and relied heavily on repetitive grid based rhythms. Genres and track selections were based on classification systems and descriptions from existing literature and researcher knowledge. In devising a new method of analysis while addressing perceived ambiguity, it was necessary to put each style within musical context.

2.1 Breakbeat

Breakbeat, or Breaks, is an EDM genre popularized within the 1990s and is derived from the use of sped-up samples of drum-breaks found in Soul and Funk music recordings. These patterns are also commonly associated with Hip-Hop music rhythms, as they have been sampled from similar sources (Butler 78). The arrangement of instrumental timbres and beats within each Breakbeat track are layered in order to add energy and compositional complexity. In transcribing the kick drum, snare drum and hi-hat cymbal patterns, a typical Breakbeat pattern was found to fall within a four-four measure and had an average gridded tempo of approximately 120 to140 beats-per-minute (BPM). It had beat separation with the kick drum placed on beats 1 and 3 and snare drum on beats 2 and 4. The hi-hat tended to occur as an off-beat on every other eighth note (See fig. 1). An example of this typical Breakbeat pattern can be heard in the Plump DJs remix of Dave Spoon's "Lummox".

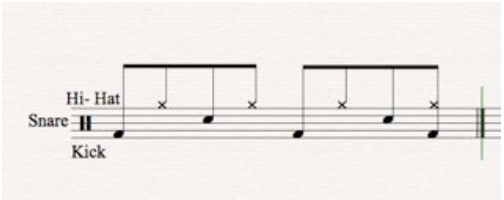


Figure 1. A one bar notated example of a typical Breakbeat rhythm.

2.2 Drum and Bass

Originating the UK in the late 1980s and early 1990s, Drum and Bass, or Jungle, has its origins in Hip-Hop, Breakbeat and reggae bass rhythms. Its four-four Breakbeat-based rhythms are sped-up to roughly 150 - 180 BPM. Drum and Bass relies heavily on its bass line, and is commonly layered with low frequency, or sub-bass, timbres. Through transcription, one of the distinguishing rhythmic features of a Drum and Bass beat was the presence of the snare drum placed on the second and fourth beat of every bar like Breakbeat, but at a much faster tempo (See fig. 2). An example of a typical Drum and Bass pattern can be heard in Brookes Brother's "Tear You Down".

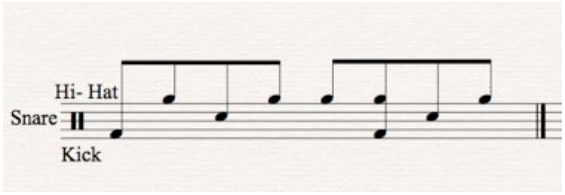


Figure 2. A one bar notated example of a typical Drum and Bass rhythm.

2.3 Dubstep

Within the last 6 years or so, Dubstep has become a more popular form of EDM, originating from the UK. Its rhythms arguably have been derived from the half-time feel of dub reggae rhythms and the faster hi-hat rhythms of the subgenre 2-step Garage. Over the last few years, variations in Dubstep production techniques and trends have started to challenge what the one might call the "typical" Dubstep sound. Aside from of this notion, a common factor is its four-four-tempo range lying between 130 to 142 beats per minute. A distinguishing rhythmic feature of Dubstep is that the kick drum is usually placed on the 1st beat, with the snare drum typically placed on the third beat of every bar (See fig. 3). Another aurally distinguishable characteristic of Dubstep is a synthesized bass line that consists of rhythmic low or high frequencies altered by rhythmic filter modulation: some producers refer to this as "wobble bass". Examples of a Dubstep beat-pattern can be heard in the Broke DJ's remix of DJ Shadow's "Blood On The Motorway".

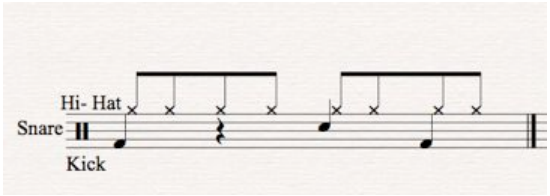


Figure 3. A one bar notated example of a typical Dubstep rhythm.

2.4 House

House music, being older than some of the other forms of EDM, has its roots in 1970s Disco, originating in Chicago and New York in the 1980's. House tracks tend to rely strongly on the repetition of a main beat that incorporates a groove between its percussive parts. House tracks are typically within the four-four-tempo range of 120 to 130 beats per minute. A main defining feature of House is the use of a kick drum placed on the quarter note beat of every bar, also known as "Four to the Floor". The snare drum tends to be on beats 2 and 4 with the eighth beat off-beats on the hi-hat (see fig. 4). With House music relying on so much repetition, some tracks were strategically arranged to allot for variety and richer structure and harmonic complexity. An example of a typical House pattern can be heard in Michael Gray's "The Weekend".

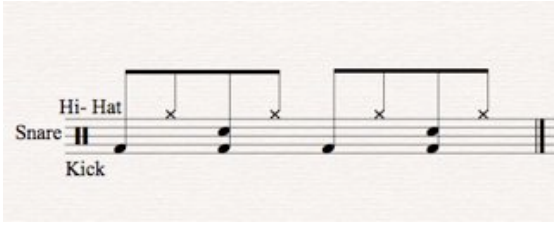


Figure 4. A one bar notated example of a typical House rhythm.

3. Analysis

Throughout the analysis, there were distinctive rhythmic and timbral qualities that were used to classify each of the four genres chosen. In order to classify each track, various commonalities had to be quantified by way of a devised approach to EDM transcription. This approach involved collecting data using Ableton Live[1] for human analysis and track deconstruction, MAXMSP/Jitter[2] for machine learning and pattern labeling, and Google Docs[3] for a multi-track analysis database. The data collected from each transcription provided the details of rhythms and instrumental densities in the research database. To simplify the analysis, each track was transcribed from the bottom up (focusing on the smallest parts of what makes a typical beat) as well as top down (focusing on how a typical track's structure is arranged).

3.1 Beat Structure

Of the multitude of sub-genres that constitute EDM, most rely on looping the strong rhythmic structures, or beats. As production techniques are somewhat ambiguous and vary with each track, not all beats are the same. Since these EDM genres relied so heavily on similar rhythms tied to a grid, it was determined that the beats alone could be analyzed to help distinguish one genre from the other. At the bottom level, the analysis focused on the

[1] http://www.ableton.com
[2] http://www.cycling74.com
[3] http://docs.google.com

distinctive drum rhythms and complex layering of timbres in each track. At this level, each beat pattern was analyzed for its timbral and rhythmic qualities, typical of that specific genre. There were inconsistencies with some beat patterns that needed to be considered. For example, some patterns were found to be longer than expected, such as a 2 bar pattern instead of a typical one bar pattern. There was a heavy layering of instrumentation that obscured some of the underlying beats, or was obscured by a one bar drum fill for variation. Furthermore, signal processing would often obscure the rhythm. At times, there were also variations of the beat, or a complete drop-out, of a rhythmic instrument, usually done for effect.

To be aware of inconsistencies and avoid confusion of what to listen for in each beat loop, analysis was initially focused on isolating the kick drum, the snare drum and hi-hat patterns of each track. Each recording was imported into Ableton Live, and used the software's time-warp features to adjust each beat to be properly and consistently aligned within a 1/16th note subdivision grid (see fig. 4). As such, each track's tempo was known, and analysis could focus upon the subdivisions of the measures. To further quantify the beat analysis of each track, the 16th note values of the individual kick, snare & hi-hat patterns of the most defined beats were converted into 16-bit binary and hexadecimal values, with each onset receiving an on-bit (see figs. 5 and 6).

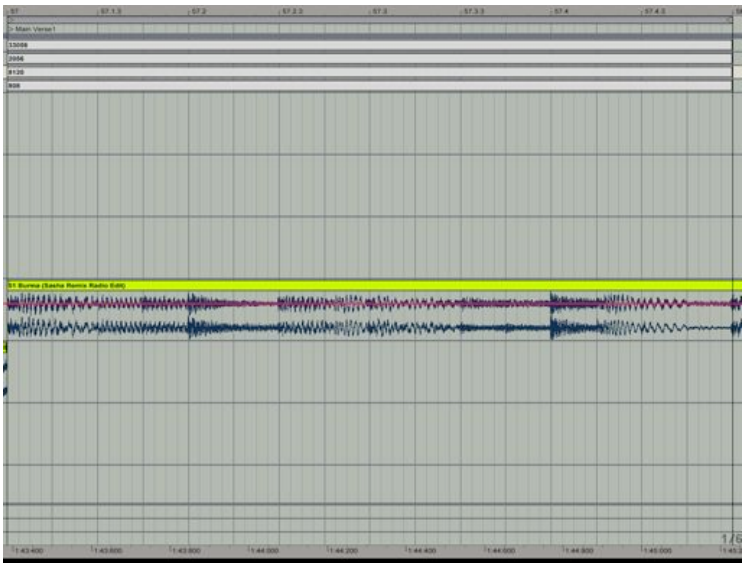


Figure 4. An isolated beat pattern with its transients mapped to the grid in Ableton Live.

Figure 5. The most common beat output as a 16th note decimal value.

Figure 6. The most common beat output as a 16th note hexadecimal value.

A database was then created in Google Docs for storing the data of each track (see fig. 7). This data was used to help differentiate one track from another based on various quantified features.

The features listed were:

- Tempo
- Number of measures
- Number of measures with beats
- Number of unique beat patterns
- Length of pattern (1 or 2 measures)
- Average kicks per pattern
- Average snare hits per pattern
- Number of instrumental parts per beat pattern
- Number of fills

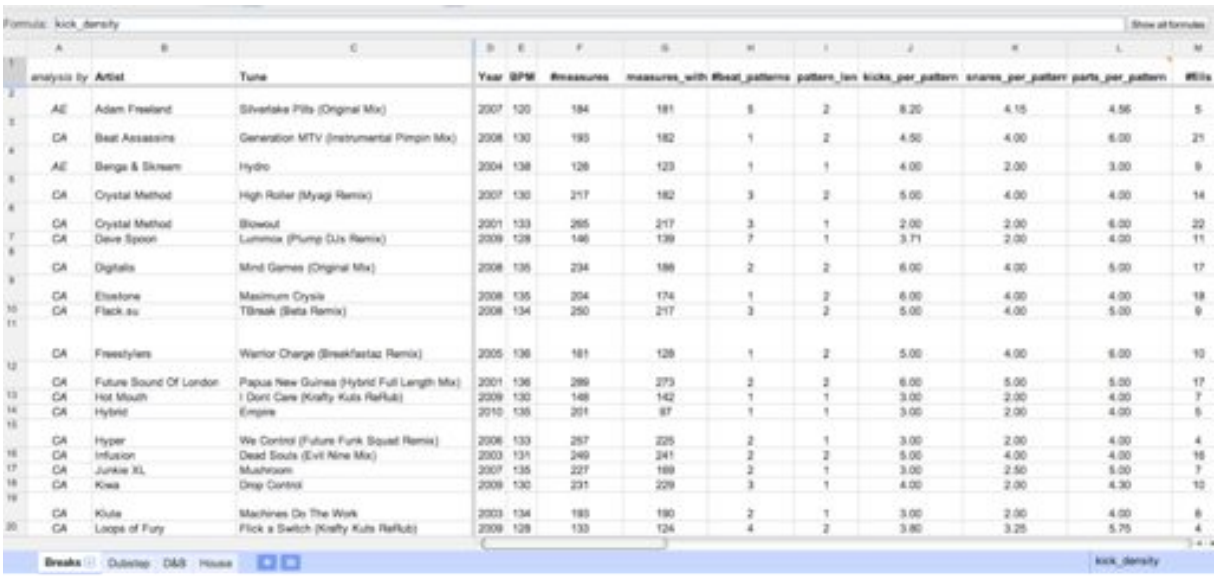
From these data areas, these following additional distinctive features were derived:

1. Kick density =
(number of measures with beats / (pattern length / kicks per pattern))

2. Snare density =
(number of measures with beats /(pattern length / snares per pattern))

3. Density percentile =
(number of measures / number of measures with beats)

4. Change percentile =
(number of measures / number of unique beat patterns)



analysis by	Artist	Tune	Year	BPM	#measures	measures_with	#beat_patterns	pattern_len	kicks_per_pattern	snares_per_pattern	parts_per_pattern	#fills
AE	Adam Freeland	Silverlake Pills (Original Mix)	2007	120	184	181	5	2	8.20	4.15	4.56	5
CA	Beat Assassins	Generation MTV (Instrumental Pimpin Mix)	2008	130	193	182	1	2	4.50	4.00	6.00	21
AE	Benga & Skream	Hydro	2004	138	128	123	1	1	4.00	2.00	3.00	9
CA	Crystal Method	High Roller (Myagi Remix)	2007	130	217	182	3	2	5.00	4.00	4.00	14
CA	Crystal Method	Blowout	2001	133	265	217	3	1	2.00	2.00	6.00	22
CA	Dave Spoon	Lummox (Plump DJs Remix)	2009	128	146	139	7	1	3.71	2.00	4.00	11
CA	Digitalis	Mind Games (Original Mix)	2008	135	234	188	2	2	6.00	4.00	5.00	17
CA	Elsefone	Maximum Crysis	2008	135	204	174	1	2	6.00	4.00	4.00	18
CA	Flack.su	TBreak (Beta Remix)	2008	134	250	217	3	2	5.00	4.00	5.00	9
CA	Freestylers	Warrior Charge (Breakfastaz Remix)	2005	136	161	128	1	2	5.00	4.00	6.00	10
CA	Future Sound Of London	Papua New Guinea (Hybrid Full Length Mix)	2001	136	289	273	2	2	6.00	5.00	5.00	17
CA	Hot Mouth	I Dont Care (Krafty Kuts ReRub)	2009	130	148	142	1	1	3.00	2.00	4.00	7
CA	Hybrid	Empire	2010	135	201	87	1	1	3.00	2.00	4.00	5
CA	Hyper	We Control (Future Funk Squad Remix)	2006	133	257	225	2	1	3.00	2.00	4.00	4
CA	Infusion	Dead Souls (Evil Nine Mix)	2003	131	249	241	2	2	5.00	4.00	4.00	16
CA	Junkie XL	Mushroom	2007	135	227	189	2	1	3.00	2.50	5.00	7
CA	Kiwa	Drop Control	2009	130	231	229	3	1	4.00	2.00	4.30	10
CA	Klute	Machines Do The Work	2003	134	193	190	2	1	3.00	2.00	4.00	6
CA	Loops of Fury	Flick a Switch (Krafty Kuts ReRub)	2009	128	133	124	4	2	3.80	3.25	5.75	4

Figure 7. This is a small sample of the Google Docs database.

A software classifier was used to create a C4.5 Decision-Tree analysis (J48)[4], based on these additional features. Since song tempo was such a strong defining feature of a genre, it was ignored in order to look for other possible distinguishing features. From this analysis, it was shown that the snare and kick densities in Dubstep and House tracks were different from those of the other genres. The percent of change, and these densities also separated Drum and Bass from Breakbeat. Also, in contrast to the computer, the human analysis was deemed less likely to account for snare and kick density as a useful feature for classification.

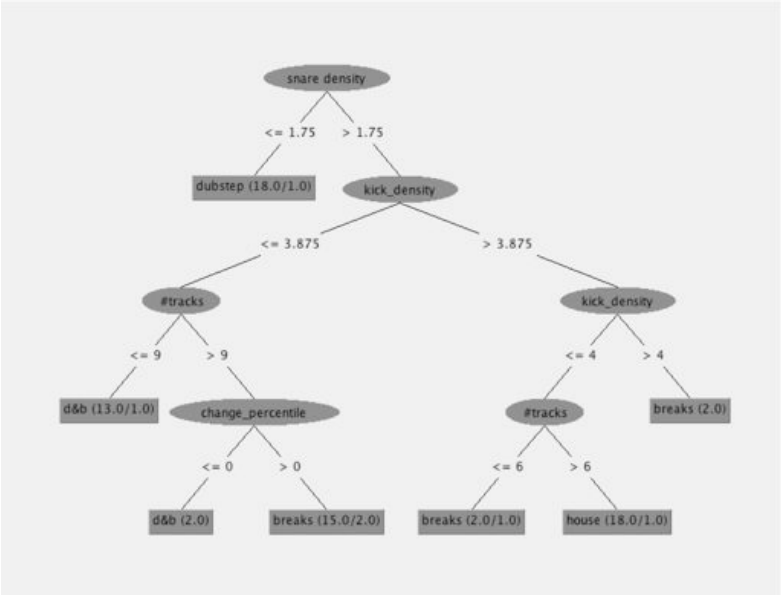


Figure 8. This is an image of the decision-tree classifying each track based on its features

[4] http://www.cs.waikato.ac.nz/ml/weka/

3.2 Form

EDM song structures can be quite varied depending on how the original composer or producer has arranged the track. Upon researching each track, many seemed to have been crafted using a specific set of production rules and techniques. Since many of these tracks were composed to be mixed live by DJs, certain sections of each track's form were analyzed as transition points, as seen to easily move between one track to the other or to build energy in a specific part of the piece. For most DJs, it seems important to know where the formal sections lie, but where one DJ may think there are changes in the form another may hear the structure differently. Of the EDM genres analyzed, one of the challenges has been defining one section of the track's form to another. It then became necessary to generate a set of rules to distinguish one section from the other. One possible solution was to listen for changes in rhythm or timbre. Such as, looking for purposeful silence or breaks in timbral density or the layering of new timbres upon others at specific points.

In order to analyze the form of each track, phrases were separated into sections, much like other popular music genres, and then labeled. As there was only one listener per track and other listeners could possibly label each section in a different place based on their interpretation, with five labels being used to distinguish the various sections of each track:

• Lead-in – This is the first section with often only a single layer or basic beat pattern present. A DJ typically uses this section to match the tempo of a previous track in with the tempo of the current track.

• Intro – In this section the main beat is established and will likely lead to the 1st verse or Breakdown section that leads to the 1st verse. There are more instruments, such as the bass, but it is not as full as the Verse.

• Verse – These are the fullest sections of the track, in which all instruments are present. These occur several times and are usually preceded by a Breakdown section. Depending on the genre, each initial onset of a verse after a Breakdown is sometimes known as "The Drop", where the full beat instrumentation re-enters.

• Breakdown – Is a contrasting section to the verse in which the beat may drop out, or a filter may remove all mid and high–frequencies. It will tend to build tension, and lead back or crescendo to the verse in anticipation of "the drop".

• Outro – This section is the fade-out or extended lead-out of the track, which can be used by DJs to transition between tracks at the same tempo.

Each track's complete structure was catalogued with letters representing the different phrases and sections for every 8 bars. Each number represents whether an instrument or other timbre is present during a given phrase or section. The labels of each section were as such:

A – Lead-In

B – Breakdown

C – Main Verse

D – Breakdown

E – Outro/Lead-out

Fills were labeled F and are being analyzed for their variation properties in the form. The structures found within the tracks analyzed were unique, with no duplication.

Figure 9. Here is an example of how the form of the tracks are deconstructed in Ableton Live

Section breaks were difficult to define at certain locations in each track. The addition of certain instruments or the onset of timbre was used to determine some sections although, the order of which was not consistent. Certain specific timbres were heard as sectional boundaries, but while determining these timbres was not a difficult task for our human analysis, it seemed an extremely difficult task for future machine analysis. Because of the subjective nature of labeling each section, many of the structure labeling decisions were seen as debatable.

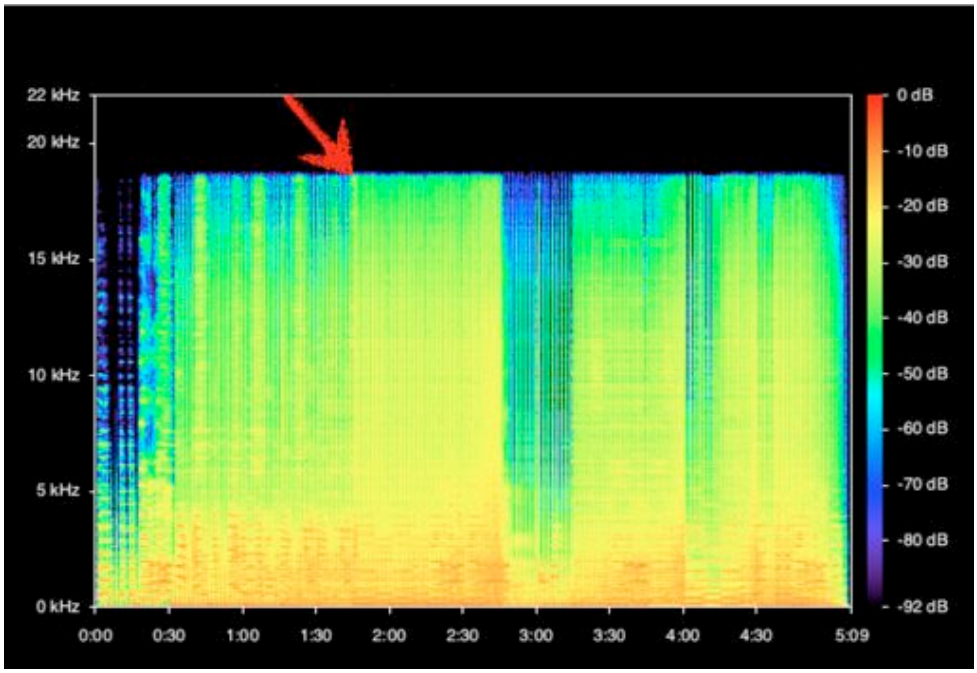


Figure 10. This is the spectrogram of a Breakbeat track (Lostep - Burma (Sasha Remix).

You can see in Figure 10 that the section changes in the spectrum. This demonstrates how the timbre of each section changes in each track. You can also see from this sample that lower frequencies like the kick drum are far denser and that the high end is chopped due to MP3 compression.

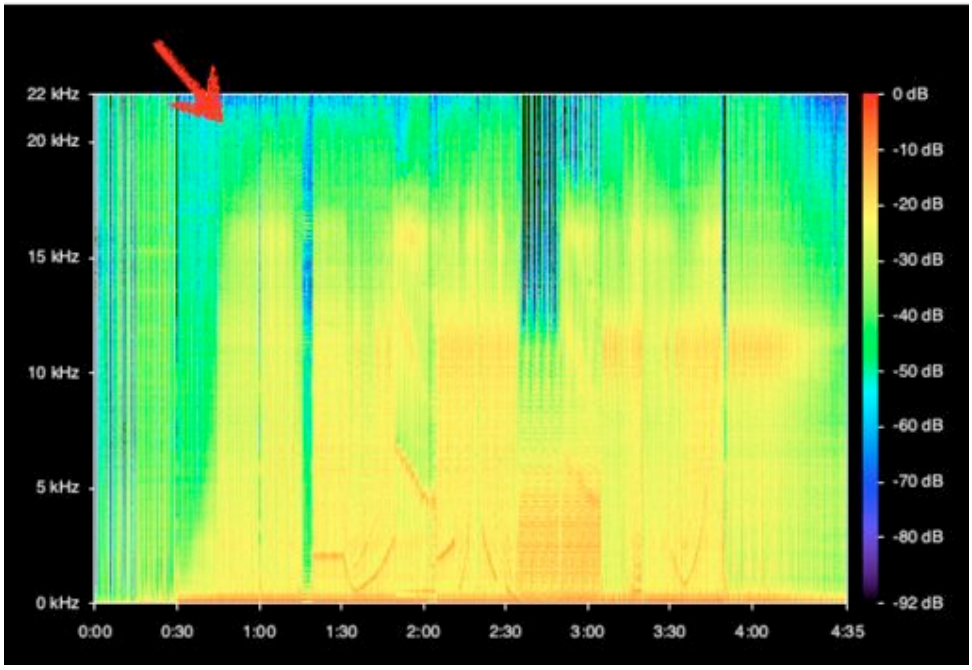


Figure 11. In contrast, this is the spectrogram of another Breakbeat track (Dave Spoon - Lummox (Plump DJs Remix).

The sample in Figure 11 is also from the transition of the Intro section to the main Verse section. This track, unlike the other piece, incorporates a fill to transition between sections. There are noticeable filter sweeps and brick-wall compression. As both samples demonstrate clear timbral transitions between the sections, defining each formal position is still debatable.

4. Conclusion

The GERP is now analyzing the bass-lines, drum fills, drop outs and timbral complexities of the other instrumental parts in each track. Signal processing, such as compression, rhythmic gating, filters, delays and production techniques are also being analyzed to better understand their use in compositional design. The human-informed machine learning conducted so far has shown that there are no obvious form differences in phrase lengths. So, as this level of accuracy increases, there will be a push to further engage machine learning to help move away from using too much intuition. This further research will help to find more significant methods of differentiating EDM genres and increase the size of the GERP EDM database. It then will grow through the use of stronger more accurate machine analysis.

This analysis will be used to research the generation of rhythmically and timbrally rich compositions that, at a higher level, will be comparable to the standards of EDM production values. Parts of this work will help in creating new methodologies that can be engaged on a critical level and hopefully engage in creating new discussions about other forms of electroacoustic music.

Acknowledgements

Thanks to Dr. Philippe Pasquier, Alan Ranta, Tristan Bayfield, and David Mesiha for their work and insight into GERP. This research was funded in part by a New Media grant from the Canada Council for the Arts.

References

Adamo, Mike. *The Breakbeat Bible*. Briarcliff (NY), Hudson Music, 2010. Print.

BROOKES BROTHERS. "Tear You Down." Breakbeat Kaos, 2008. WAV File.

BUTLER, Mark Jonathan. *Unlocking the Groove: Rhythm, Meter, and Musical Design in Electronic Dance Music*. Bloomington, (IN), Indiana University Press, 2006.

CHAI, Wei. "Automated analysis of musical structure." *Media,* 2005, pp, 1-96.

COLLINS, Nick. "Infno: Generating Synth Pop and Electronic Dance Music On Demand." *Proceedings of the International Computer Music Conference*. Belfast, 2008, pp,1-4.

DIAKOPOULOS, Dimitri et al. "21 ST CENTURY ELECTRONICA : MIR TECHNIQUES FOR CLASSIFICATION AND PERFORMANCE New Zealand School of Music." *10th International Society for Music Information Retrieval Conference*. ISMIR, 2009. pp. 465-469.

DJ SHADOW. "Blood On The Motorway (Broke DJs Remix)." MCA, 2009. WAV File.

EIGENFELDT, Arne, and Philippe PASQUIER. "Towards A Generative Electronica: Human-Informed Machine Transcription and Analysis in MaxMSP", Web, 2011. <http://www.sfu.ca/~eigenfel/TowardsGenerativeElectronica.pdf>

GRAY, Michael. "The Weekend." Ultra, 2004. WAV File.

KLAPURI, Anssi & Manuel DAVY. eds. *Signal Processing Methods for Music Transcription*. New York (NY), Springer, 2006, pp. 3-20. Print.

Landy, Leigh. *Understanding the Art of Sound Organization*. Cambridge (MA), MIT Press, 2007. Print.

LOSTEP. "Burma (Sasha Remix)." Global Underground, 2004. MP3 File.

MADDAGE, Namunu C. "Automatic Structure Detection for Popular Music." *Ieee Multimedia* 13.1, 2006, PP. 65–77.

REYNOLDS, Simon. *Generation Ecstasy : into the world of techno and rave culture*. Boston (MA), Little, Brown, 1998. Print.

SHAPIRO, Peter. , ed. *Modulations : A History of Electronic Music*. Ney York (NY), Caipirinha, 2000. Print.

SNOMAN, Rick. *The Dance Music Manual : Tools, Toys and Techniques*. Burlington (MA), Focal Press, 2005. Print.

SPOON, Dave. "Lummox (Plump DJs Remix)." Televizion, 2009. WAV File.