The Generative Electronic Dance Music Algorithmic System (GEDMAS)

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Abstract

The Generative Electronic Dance Music Algorithmic System (GEDMAS) is a generative music system that composes full Electronic Dance Music (EDM) compositions. The compositions are based on a corpus of transcribed musical data collected through a process of detailed human transcription. This corpus data is used to analyze genre-specific characteristics associated with EDM styles. GEDMAS uses probabilistic and 1st order Markov chain models to generate song form structures, chord progressions, melodies and rhythms. The system is integrated with Ableton Live, and allows its user to select one or several songs from the corpus, and generate a 16 tracks/parts composition in a few clicks.

Introduction

For over two years, the Generative Electronica Research Project group (GERP), from within Simon Fraser University's Metacreation, Agent, and Multi-Agent Systems Lab (MAMAS) have been actively researching generative Electronic Dance Music (EDM). Specifically compositions or songs of the subgenres Breakbeat, House, Dubstep, and Drum and Bass, have been researched and analyzed for their use within new corpus-based generative music systems. So far, two generative music systems have resulted from our research: Generative Electronica Statistical Modeling Instrument (GESMI)[1] created by Arne Eigenfeldt and Generative Electronic Dance Music Algorithmic System (GEDMAS) created by Christopher Anderson (Eigenfeldt and Pasquier 2013). As demonstrated in earlier work[2] (Eigenfeldt and Pasquier 2010), and in systems such as David Cope's EMI, our corpus-based generative music systems are not based on an entirely new or unique concept (Cope 1991). Our research in GERP however, has been focused on examining new ways to transcribe, analyze, and exploit a transcription-data-rich canon of EDM for the purposes of unique metacreation and generative systems research.

Overview

GEDMAS was initially designed as a system to test software interaction between MaxForLive/MaxMSP and Ableton Live's application programming interface (API). As many EDM producers already use Live[3], this testing software helped to enable us to understand Live's potential as a music production host for our systems. GEDMAS was also used to examine if MaxForLive/MaxMSP would suffice as a programming platform for creating generative systems that can interact with Live. GEDMAS was later redesigned to test for corpus transcription accuracy to help prepare the data for use in other systems such as GESMI.

GEDMAS has since been redesigned to probabilistically model and generate EDM in real-time based on the data from our analysis corpus. Our data was collected by extensively transcribing the song form, rhythms, melodies, harmonies, and timbres of each song. 100 songs initially were chosen to reflect common musical features and characteristics associated with the Breakbeat, House, Dubstep, and Drum and Bass. These included bottom-level features such as timbre, rhythmic/melodic patterns, and top-level features such as common tempos and song form structures. For now, GEDMAS is only referencing 24 Breakbeat songs from our transcription corpus.

Through our early analytical tests, we determined that the music in our corpus was too timbrally dense to utilize certain computer-based methods and tools for music information retrieval and feature extraction. Instead, we opted to transcribe and quantify each song by ear based on select criteria that would best represent the songs in written data form. Ableton Live was chosen to be the host software to conduct transcriptions since it enabled us to tie each song's transients to a grid. Each song is cut and organized into song form sections. The transient mapping enabled us to visibly check our pattern onset/transcription

[1] https://soundcloud.com/loadbang
[2] http://youtu.be/5lz2jT_1JtY
[3] http://www.ableton.com/live

accuracy as well as slow the tempo to hear each section in detail. Because we do not have a large group of transcribers, we are subject to possible human error. We are now attempting to mediate any human error during transcription by transcribing each instrumental pattern as a parallel midi pattern to the original recording in the arrangement. This allows for future A/B testing of the transcription material as well as eliminating errors in formatting the transcription data.

GEDMAS generates full songs by running through five main stages:

1. Overall Form Generation
2. Chord Progression Generation
3. Instrumental Onset Generation
4. Pattern Generation
4. Data Transfer and Playback

Corpus data is mined from our transcription spreadsheet. The data is prepped and stored in the GEDMAS Max 6 application. Using a series of subroutines this data is then analyzed and used to generate form and rhythmic, melodic and polyphonic pattern data. Once generated, this data is sent from the GEDMAS application to a MaxForLive patch housed within a custom Ableton Live Set. The pattern data received by the MaxForLive patch is then used to fill the MIDI sequence clips in Ableton Live. The form data received by the patch is then used to playback each pattern in sequence.

Overall Form Generation

In our transcriptions, we have labeled each section of the form according to its function in the song structure. This data is then used for form analysis and generation as demonstrated in earlier versions of GESMI[4] (Eigenfeldt 2011).

A1 A2 A3 A4 B1 B2 B3 B4 D1 D2 D3 D4 D5 D6 D7 D8 D9 C1 C2 C3 C4 E1 E2 E3 E4

Figure 1. *The transcribed form of Hybrid's Empire*

As an example, Figure 1 represents the full form of a Breakbeat song called Empire. Each numbered capital letter represents an 8 bar phrase within the song, therefore this song consists of 200 bars. GEDMAS borrows this labeling approach from GESMI, but also incorporates a method of grouping and labeling each individual 8 bar section into larger groupings of the form. Each grouped section from Figure 1., would be labeled as 1A 1B 1D 1C 1E. This macro-level labeling is used for the analysis and generation of longer events within the form, such as chord progressions that may repeat longer than an 8 bar section.

GEDMAS generates forms by way of a 1^{st}-order Markov chain transition table. Each new section is collected in sequence order and is then converted back into a numbered lettered format as well as at the macro-level.

[4] http://cec.sonus.ca/econtact/14_4/eigenfeldt_generativeelectronica.html

		8 bar Sections and Probability of Next Section							
		A1	A2	A3	A4	A5	A6	B1	B2
Possible Next Sections	A1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	A2	87.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	A3	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
	A4	0.0	0.0	88.9	0.0	0.0	0.0	0.0	0.0
	A5	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0
	A6	0.0	0.0	0.0	0.0	100.	0.0	0.0	0.0
	B1	12.5	75.0	11.1	25.	0.0	100.	0.0	0.0
	B2	0.0	0.0	0.0	0.0	0.0	0.0	91.7	0.0
	…								

Figure 2. *A section of the 1^{st}-order transition matrix of the transcribed forms.*

Chord Progression Generation

The chord progressions of each 8 bar section in the corpus songs have been transcribed and are stored as strings of chord symbols. The newly generated form is used to select this chord progression data from the appropriate songs and forms in the corpus. Each chord progression selected is also analyzed and labeled at a macro-level for its occurrence beyond 8 bars in the song form. Each new chord progression is later connected to macro-level sections of the form.

After analyzing the corpus based on the form of the new song, a table of chord onset probabilities is filled. This table is used to generate new chord progressions for the sections in the new song. These new chord progressions are also used to define the pitches to be used in generating the melodies and harmonies while creating a level of horizontal (i.e., temporal) coherence between the instruments. Chord progression generation is based on calculating probabilities of chord onset occurrences in each form. Future versions of GEDMAS will generate chord progressions based on a Markov chain model.

Instrumental Onset Generation

Once the form and chord progressions have been generated, onsets indicating what instrumental patterns are to be played, and when, are generated. A table of form onset probabilities is first created for the onsets in the corpus. The instruments have been divided and analyzed based on their respective timbre. The instruments are: Main-Beat Kit (Kick, Snare, Closed Hi-hat, Open Hi-hat), Auxiliary Percussion (Claps, Crash Cymbal, Bongos, Shakers etc.), Auxiliary Percussion 2, Bass, Bass2, Rhythm Synth 1, Rhythm Synth 2, Melodic Synth 1, Melodic Synth 2, Pads, Keyboards, Drones, Atmospheric, Ancillary Instrument 1 (Other Melodic or percussive instruments), Ancillary Instrument 2, Ancillary Instrument 3, Ancillary Instrument 4, Ancillary Instrument 5.

For every 8 bar section in the overall form, the 16 instrumental pattern onsets are stored as integers to represent which rhythmic or melodic pattern is playing for a particular instrument. Each instrument may have up to 8 different patterns indicated by the integers 1 to 8. The limit of 8 patterns per instrument was chosen to reflect the extent of Breakbeat patterns in the corpus. This limit will change once GEDMAS incorporates other genres of the corpus. Tacet instruments are indicated with a 0. Percussive instruments/tracks include four instruments/parts, so an extra integer from 1 to 15 is added to the front of the pattern number to indicate numerically which combination of four instruments is playing. For example, a pattern symbol of "1 3" for the main-beat kit would indicate that the 3rd pattern is selected and only the kick drum would be playing whereas "15 1" would indicate pattern 1 is selected and all instruments in the kit are to be played. Each instrumental pattern onset is generated based on another probabilistic table of percentages collected and analyzed from the corpus. Each new pattern onset is then tied to one of the newly generated chord progressions and form. Instrumental patterns that repeat and follow the chord progressions are kept, while the pattern onsets that will not fit harmonically are regenerated until they match.

Bars	Instrumental Tracks and Onsets							
	Mbeat	Ax1	Ax2	Bass	Bass2	Rsyn	Rsyn2	…
1	10 1	5 1	1 0	0	0	0	0	
8	4 1	4 1	3 1	0	0	0	0	
16	15 1	13 1	3 0	1	0	0	0	
24	15 2	10 1	3 2	1	0	0	0	
32	15 1	4 1	7 1	1	0	0	0	
40	15 1	4 0	3 1	2	0	1	0	
48	15 2	10 1	2 1	1	0	0	1	
56	10 0	1 0	3 0	1	0	0	0	
…								

Figure 3. *A portion of a generated form score and pattern onsets.*

As seen in Figure 3., each form section letter label is then converted to a bar number representing every 8 bars in the form. These bar numbers are combined with the instrumental pattern onsets to form the score. This score is used for populating the 16 Ableton Live tracks with the various MIDI patterns to be generated next.

Pattern Generation

Prior to generating each pattern the GEDMAS user interface allows the user to select a root key for all melodies and harmonies. MIDI velocities are globally set for all patterns. Each melodic pattern is generated by analyzing the probabilities of note onsets, duration, rests, and pitch values found within each 8 bar phrase. Each melody is transcribed by using a midi keyboard as a guide for pitch and a metronome as a guide for rhythmic onsets and duration. The transients of onsets are also examined to visually inspect transcription accuracy. Since the root key has differed between most songs, the melodic note onsets are represented by 12-tone pitch-class notation. This format better reflects an intervallic relationship in any key and simplifies the analysis. Each note, duration or rest is represented as a character in a 128-character string where each of the characters in represent a 16^{th} note in the 8 bar sequence.

. . 12 12 - 10 - - 12 12 - 7 - 5 7 - . . 15 19 - 14 - - 26 26 - 26 - 26 26 -

***Figure 4**. A section of an ordered pitch-class melodic pattern*

Prior to the generation of a melodic sequence, the melodic patterns from the corpus are selected based on the newly generated form, harmony and instrumental onsets. The newly generated instrumental onsets indicate how many patterns are to be generated for each instrument. Borrowing from GESMI and as seen in Figure 4., the corpus melodic pattern data is split into three parts: note/rest onsets, pitch onsets and note durations. Each note/rest onset is first to be generated and is represented by either a number or a period ".". This is followed by the generation of pitches indicated by a pitch-class note value. Then a duration for each pitch is generated, indicated by a hyphen "-". Each pitch is quantized to the chord tones associated with its chord progression. The pitches, rests and durations are overlaid with the note onsets and placed in sequence. This melodic pattern sequence data is then formatted for the Ableton Live MIDI clip slot.

When generating the pattern melodies and subsequent polyphony for the pads, keys, drones, atmospheric and ancillary instruments an initial 8-bar melody is generated. Then the additional polyphonic voices are generated based on the probabilities of intervals from the root notes. More advanced voice-leading analysis will be used in newer versions of the system.

Data Transfer and Playback

When GEDMAS has finished generating the form, score and patterns, the data is then sent to the GEDMAS Max-ForLive patch using Open Sound Control network messages. The pattern data is parsed and placed into the appropriate MIDI clips in Ableton Live's session view via the Live API[5]. The user can then press play on the patch, which engages Live and sends its transport clock data to the score player. The score player keeps track of which bars are playing and launches each MIDI pattern clip according to the onsets in score. The score is played like a piano roll or tracker sequencer in real-time and can be recorded to Live's arrangement view for further editing, mixing and mastering. As Live is a host to many of its own and third party virtual instrument plug-ins, each generated song can be transformed based on the chosen instrumental timbres. For the moment the user is in control of selecting these instrumental timbres and signal processes.

Past, Present and Future

So far, GEDMAS has been presented on YouTube[6], SoundCloud[7] under the alias Pitter-Pattr, and at the 2013 Musical Metacreation Weekend[8] Algorave in Sydney. Future versions of GEDMAS will incorporate subtlety and variety in each song with the generation of drum fills, one-hits, and generative instrument selection. We are expanding our GERP[9] analysis corpus to cover a wider range of EDM generation and looking to create other systems that will explore generative music in live performance and generative DJing.

As with most other corpus-based generative music systems GEDMAS will require in-depth research to fully evaluate its successes and failures in composing EDM. Future versions of the system will be tested in the field to receive valid feedback from EDM producers. Other research will involve assessing the system's aesthetics and validity in a live setting as well as conducting comparison study of the two GERP systems.

There are also challenges to be met in improving our transcription methods. This will include improving the measurement of transcription accuracy, using MIR tools to simplify pattern extraction, simplifying the transcription method to allow others to build their own corpus and use GEDMAS in different ways.

Sections of GEDMAS will be used in the development of new computer-assisted composition tools as well as tools for algorithmic live performances.

Acknowledgements

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[5] https://www.ableton.com/en/live/max-for-live/
[6] http://youtu.be/BreNNvwcr0U
[7] https://soundcloud.com/pitter-pattr
[8] http://www.metacreation.net/mumewe2013/
[9] http://www.metacreation.net/gerp

References

Ableton. Accessed July 12th, 2013. http://www.ableton.com

Butler, M. 2006. Unlocking the Groove: Rhythm, Meter, and Musical Design in Electronic Dance Music. Bloomington, Indiana University Press.

Cope, David. 1991. Computers and musical style. Madison, Wisconsin A-R Editions.

Eigenfeldt, A. 2011. Towards a Generative Electronica: A Progress Report. *eContact!* 14.4 http://cec.sonus.ca/econtact/14_4.

Eigenfeldt, A., and Pasquier, P. 2013. Considering Vertical and Horizontal Context in Corpus-based Generative Electronic Dance Music. Submitted to: International Conference of Computational Creativity, Sydney.

Eigenfeldt, A., and Pasquier, P. 2013. Evolving Structures For Electronic Dance Music. Submitted to: Genetic and Evolutionary Computation Conference (GECCO). Amsterdam.

Eigenfeldt, A. & Pasquier, P. 2010. Realtime Generation of Harmonic Progressions Using Controlled Markov Selection. In *Proceedings of the First International Conference on Computational Creativity (ICCCX),* 16-25. Lisbon, Portugal: ACM Press.

Hybrid. 2010. "Empire". *Disappear Here*. Distinct'ive Records. Mp3.