The Dynamic Pulse: Bringing Aleatoric Hip-Hop to Life

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Introduction

Can a computer be given soul? In an attempt to harness the power of aleatoric music, in June of 2011, I invented an algorithm that merges the synthetic decision making capability of computer software with the emotion of a human musician. This I call this the Dynamic Pulse. With each push of the “Play” button, the Dynamic Pulse randomly sequences a new composition from a vast library of melodic song fragments. To evoke emotion, velocity data from a live keyboard performance is transformed into and saved as MIDI automation. Regardless of melodic structure, each musical composition will always behave with the same emotion contained within the MIDI automation clip.

Fused to the core of three virtual instruments, The Pulse pumps emotional tension through cold computer circuits. A drum machine is equipped with eight sequential drum patterns. Pattern number one is triggered to play after a prescribed MIDI threshold value has been surpassed. As the automation MIDI value increases, the drum patterns change. Each drum pattern is different and more climactic than its preceding pattern. A polyphonic synthesizer’s low-pass filter frequency and amplitude envelope release time are controlled by the MIDI value giving a change to the synthesizer’s tonal characteristics. As the MIDI value increases, the filter and release open transforming the synth’s timbre from a dull staccato tone into a powerful legato lead. A percentage of a digital delay effects processor is added and controlled by the MIDI value creating special effects. As the MIDI value increases, echoes emerge as if the sound is heard from the edge of the Grand Canyon. Although I developed the Dynamic Pulse in 2011, my current historical research shows how my work parallels two of history’s greatest composers who used aleatoric techniques: Wolfgang Amadeus Mozart and John Cage.

Aleatoric Music

Aleatoric music is organized sound with elements of chance in the choice of pitch, tone, color, rests, durations, rhythms, dynamics, and other elements (*Webster’s* 20). An aleatoric composition is different every time it is played. In 18th century Vienna, Wolfgang Amadeus Mozart first popularized aleatoric music when his musical dice game was published (Ariza 44). In the 20th century, American avant-garde composer John Cage took aleatoric music a step further by applying indeterminate procedures in his work that modified almost every parameter in his music (Hoogerwerf 245). Today, aleatoric music has moved from the confines of sheet music into computer algorithms that self-generate new variations of music. Having worked with electronic hip-hop music for a decade, I see that “the process of generating algorithmic music by computer is now ubiquitous [and it has even become] the basis for works by popular musicians...” (Collins 2). One of many popular music sequencing software, Reason, now accommodates contemporary aleatoric musicians with an “Alter Notes” feature. This allows the software to generate variations of the musician's original ideas. Although not initially recognized as being aleatoric, many of my own compositional ideas have arisen by implementing aleatoric algorithms.

Wolfgang Amadeus Mozart

Widely known for his prodigal virtuosity at the piano and his compositional skills, Wolfgang Amadeus Mozart also popularized aleatoric music in the 18th century when his *Musikalisches Würfelspiel* (Musical Dice Game) was published in 1793. "*Musikalisches Würfelspiel*...was an early example of [an aleatoric] artistic system. The idea was to create a Minuet by cutting and pasting together pre-written sections, making selections according to the roll of...dice" (Pearson 9-10). The game allowed fans the opportunity to take part in creating a new piece of music and challenged Mozart to compose new and unpredictable compositions.

Matt Pearson calculated that with just a single six sided die, the possible song combinations increases exponentially (Pearson 10). With only "five rolls there are 7,776 possible combinations, with six rolls 46,656 [combinations exist]" (Pearson 10). With the large number of possible musical composition combinations, the probability of duplicating a previous composition is extremely low.

The idea that music could become an inclusive party game seemed to be a trend of the times. "The Mozart *Musikalisches Würfelspiel* is one of at least twenty musical dice games common in the late 18th and early 19th centuries" (Hedges in Ariza 44). I imagine after listening to such beautiful music for years, it must have been exhilarating for party guests to participate in the aleatoric process by taking turns rolling dice. Ironically, the success of Mozart's game was not felt until after his death. Of the many musical dice games that appeared, the "version attributed to Mozart was first published in 1793—two years after [Mozart's] death—by Johan Julius Hummel.… It includes two similar games: one for minuets and another for contredances" (Ariza 44). This meant that even after the new aleatoric work was composed, the guests were able to immerse themselves in their creation by dancing to it in real time.

John Cage

Although Mozart's aleatoric music only affected the order of predefined music fragments, John Cage redefined the rules of 20th century aleatoric music by allowing crucial components in his compositions to be determined by chance. Cage invoked spontaneity in all aspects of his everyday life, but his "approach to aleatoricism in his piano works is even more radical, for the element of chance affects not only structural organization but also internal compositional details" (Riley 312). It seems as though Cage wanted aspects of his music to have the ability to be entirely reconstructed on the spot. In late 1950, Cage began tossing coins to make decisions on how to compose his own music (Ross 398). Cage "followed the rules of the Chines divinatory practice of the *I Ching*, or *Book of Changes*, which uses random operations to generate any one of sixty-four hexagrams, each describing a different state of mind…" (Ross 398-399). This practice sparked new ideas in the way aleatoric music could be approached.

In 1951, Cage's *Music of Changes* was a musical composition whose piano part was generated entirely using the indeterminate practices of his experiments. "The piano cycle *Music of Changes*…depended on the *I Ching* throughout; successive rolls of the dice determined what sound would be heard, how long it should last, how loud it should be, what tempo would be observed, and how many simultaneous layers should accumulate" (Ross 399). This technique allowed for a much more immersive and in-depth experience for the pianist. It may have even felt like each piece of music was written uniquely for each pianist depending on the surroundings at the time. In 1952, Cage's success sparked him to begin writing an entire indeterminate series called *Music for Piano*. In Cage's "*Music for Piano* 21-52 compositional elements are notated by chance operations derived from the *I-Ching*, observation of the pointal imperfections contained on a blank sheet of transparent paper, and eight coin-tosses to determine the clefs. The actual performance of the work, as well as its notation, is dependent on chance elements" (Riley 312). It seems as though every aspect of Cage's *Music for Piano* was subject to chance procedures.

The Dynamic Pulse

The Dynamic Pulse is an algorithm I developed using the commercial digital audio workstation software: Propellerhead Reason 7.1.1. The Pulse takes the aleatoric decision making capability of computer software and infuses it with the emotion of a live keyboard performance. Every musician has a unique way of playing a common piece of music and musicians even play the same music differently depending on their surroundings. When a pianist presses keys progressively harder, the timbre of the notes changes. When a key is barley pressed, the tone is muffled, quiet, and dies out quickly. When a key is hammered with force, the tone is bright, loud, and takes longer to decay. Much of the emotional delivery from each musician depends on the amount of pressure applied to each key.

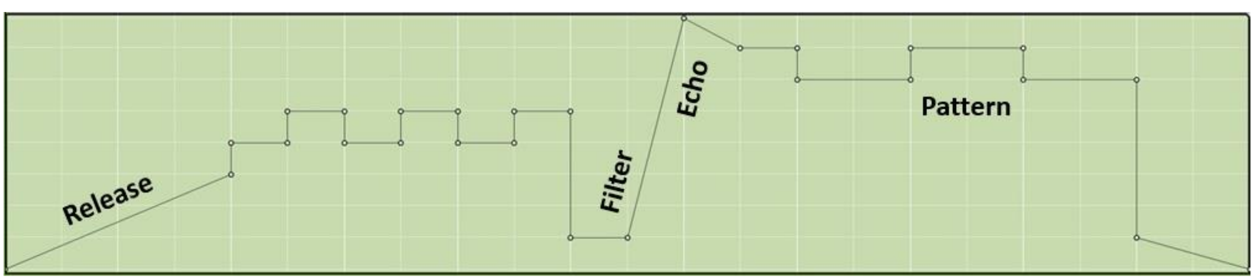

Figure 1: MIDI Automation Clip (Nathorst-Böös).

The pressure, or velocity, of the keystrokes on a MIDI keyboard is saved into Reason as MIDI data. A MIDI keyboard is a "Musical Instrument Digital Interface: a standard means of sending digitally encoded information about music between electronic devices, as between synthesizers and computers" (*Webster's* 508). This velocity data is then summed together resulting in an automation clip similar to Figure 1. The MIDI automation clip acts like an emotional template that dictates the actions of three distinct pieces of virtual equipment: a drum machine, a synthesizer, and a digital delay. Figure 1 shows the MIDI automation data used by the Pulse to add emotion to the work. The introduction of the composition begins gradually before abruptly transitioning into the first main section. Next, there is a climactic bridge; the composition then plateaus into the third section. Finally, the music fades out with a coda.

Drum Machine

A drum machine acts like a digital drummer capable of playing programmed drum patterns; the Pules uses a bank of eight patterns. As the MIDI value in Figure 1 increases, the intensity of the drums increases as well. To achieve this, the eight drum patterns build-up cyclically. "[A] traditional drum machine pattern [is] where you would record several—drum—instrument tracks and save as a complete 'pattern'. Then, you would build up your [composition] by arranging your patterns, one after another…" (Propellerhead 278). For this project, each drum pattern is one bar long, containing a unique rhythmic structure as compared to its adjacent patterns.

The MIDI automation value from Figure 1 controls the pattern number to be played by the drum machine. Each pattern has its own unique MIDI threshold value that must be surpassed to activate the pattern. As observed in Figure 1, the introduction of the composition does not meet the threshold requirement; therefore, the drums do not start playing until the first section. In the next section, the patterns switch every bar. Moving into the bridge, the MIDI value goes below the threshold stopping the drums. Very quickly, the MIDI value increases cycling through each drum pattern creating a build-up. In the third section, the patterns are much more powerful and switch every two bars. Finally, in the coda, the MIDI value goes below the threshold causing the drums to stop again.

Synthesizer Low-Pass Filter

A synthesizer is "an electronic…computerized console or module for creating or modifying the sounds of musical instruments" (*Webster's* 799). In terms of the Pulse, a synthesizer is an electronic sound wave generator. In the world of electronic hip-hop music, a synthesizer is commonly used because not only can it emulate traditional instruments, it can also create sounds that are entirely new. I can use a single synthesizer in my composition, because "synthesizers are also perfect for producing convincing reproductions of just about any acoustic or electronic instrument" (Wilson 3). In a sense, a synthesizer can be any instrument I need.

The MIDI value of the automation clip in Figure 1 changes the way the synthesizer's low-pass filter envelope behaves over time. As Rick Snoman says, "[If] the oscillator's signal is thought of as a piece of wood that is yet to be carved, the filters are the hammer and chisels that are used to shape it. Filters are used to chip away pieces of the original signal until a rough image of the required sound remains" (14). Likewise, the synthesizer can be made to sound dull or bright depending on how much the filter interacts with its sound. The low-pass filter "is used to remove frequencies above a defined cut-off point. The effect is progressive, meaning that more frequencies are removed from a sound, the further the control is reduced, starting with the higher harmonics and gradually moving to the lowest" (Snoman 14). As the MIDI value gradually increases, as in the introduction of Figure 1, the synthesizer becomes more present in the music.

Synthesizer Amplitude Envelope Release

The synthesizer is equipped with an amplitude envelope to control the volume of its sound over time. "When a key is pressed, rather than the volume rising immediately to its maximum and falling to zero when released, an 'envelope generator' is employed to emulate the nuances of real instruments" (Snoman 21). The Pulse focusses specifically on the amplitude envelope release time parameter. "The release period is the time it takes for the sound to fade from the sustain level to silence after the key has been released. If this is set to zero, the sound will stop the instant the key is released, while if a [higher] value is set the note will continue to sound, fading away as the key is released" (Snoman 22). By controlling the release time of the amplitude envelope, the synthesizer can be made to be more present in the music.

The MIDI automation value from Figure 1 controls the synthesizer amplitude envelope release time. As the MIDI value increases, the notes take longer to decay after they have been played. Unlike a piano, the length of time it takes a note to decay after the key has been released can be controlled. With a low MIDI value, notes decay almost immediately. With a high MIDI value, notes can persist for up to three seconds. In the bridge section of Figure 1, the synthesizer begins with a fast release and transitions into a slow release. This is done in conjunction with the change in the drum machine patterns and the low-pass filter opening up. The increased amplitude envelope release time compounds the build-up of intensity in the music.

Digital Delay

Digital delay is a special effect that adds an echo to the sound coming from the synthesizer. Digital delay "will allow you to delay the incoming audio signal by a predetermined time which is commonly referred to in milliseconds or sometimes in note values" (Snoman 55). This can give the effect of being far away or even standing inside a cave. The MIDI automation from Figure 1 controls the amount of digital delay that is mixed with the original sound. To better understand digital delay, I like to picture myself at the Grand Canyon. With a low MIDI value, the synthesizer sounds like it is far away from the canyon. With a high MIDI value, the synthesizer sounds like it is being played at the cliff's edge. Since the digital delay also follows the same MIDI value as the drum machine and the synthesizer, it adds energy as the music progresses.

Conclusion

The Dynamic Pulse is an automation clip containing a running number between zero and 127. As that number increases, drum patterns cycle, synthesizer envelopes transform, and energies climax. The Dynamic Pulse's ability to merge human dynamics with computerized aleatoric music paves the way for new creative possibilities. Reason software makes it able for me to generate never-ending aleaotoric compositional ideas from my own preexisting musical fragments. By using the Dynamic Pulse, I can bring these ideas to life with the soul and intelligence of my own musicality. My ongoing research demonstrates that the unique energy of my live performances can be captured and used to evoke personal expression in compositions as diverse as aleatoric hip-hop.

Works Cited

Ariza, Christopher. “Two Pioneering Projects from the Early History of Computer-Aided Algorithmic Composition.” *Computer Music Journal* 35.3 (2011): 40-56. MIT Press Journals. Web. 14 Dec. 2014.

Collins, Nick and Andrew R. Brown. “Generative Music Editorial.” *Contemporary Music Review* 28.1 (2009): 1-4. Taylor & Francis Online. Web. 15 Feb. 2015.

Hoogerwerf, Frank W. “Cage Contra Stravinsky, or Delineating the Aleatory Aesthetic.” *International Review of the Aesthetics and Sociology of Music* 7.2 (1976): 235-247. JSTOR. Web. 11 June 2015.

Nathorst-Böös, Ernst. *Reason*. Vers. 7.1.1. Stockholm: Propellerhead Software, 2013. Computer software.

Pearson, Matt. “The Organic vs. The Mechanical.” *Generative Art: A Practical Guide Using Processing*. 1st ed. Shelter Island: Manning Publications, 2011. 1-22. Web. 11 June 2015.

Propellerhead Software. (2013). *Reason: Operation Manual*. Stockholm, SE. Retrieved from http://cdn.propellerheads.se/Reason7/Manuals/Reason_7.1_Operation_Manual.pdf

Riley, Howard. “Aleatoric Procedures in Contemporary Piano Music.” *The Musical Times* 107.1478 (1966): 311-312. JSTOR. Web. 24 Nov. 2014.

Ross, Alex. *The Rest Is Noise: Listening to the Twentieth Century*. New York: Farrar, Straus and Giroux, 2007. 398-399. Print.

Snoman, Rick. *Dance Music Manual: Tools, Toys and Techniques*. 2nd ed. Amsterdam: Focal, 2009. 14-180. Print.

Webster's Universal College Dictionary. New York: Gramercy, 1997. 20-799. Print.

Wilson, Ray. *Make: Analog Synthesizers*. Sebastopol, CA: Maker Media, 2013. 3. Print.