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An Analysis of Debussy's 'Clair De Lune' Using Symbolic Representation

Introduction

Symbolic representation in a musical context simply refers to the way in which we use symbolism to represent or codify music. Traditionally western music has been represented in musical notation on staffs. On one hand this format has standardized and streamlined the process by which complex pieces of music could be recorded and shared, yet on the other it helped foster an environment in which the understanding of music notation was set aside for an exclusive audience, one with access to the tools and resources to learn this entirely auxiliary language along with its alphabet. With technological advancements in the last couple decades we are no longer limited to this singular portrayal and can instead take multiple symbolic representations of a single piece, looking at them through a variety of lenses. Starting with my own perceptual insights of Debussy's Clair de Lune I sought to combine a multifaceted approach to understanding the piece. This approach includes global and temporal audio feature extraction, along with midi analysis to help inform my own understanding of Debussy's masterful work of art.

About the piece

This project afforded me an opportunity to study something outside of my comfort zone. I chose a classical piece because it is a genre of music I am wholly unfamiliar with, yet when it comes to symbolic representation, it provides perhaps the most sound [- forgive the pun -] foundation and framework for analysis.

The song I have chosen to work with is 'Clair de Lune' by Claude Debussy, a french composer. 'Clair de Lune' was written as a standalone piece in 1890, when the composer was just 25 years of age, but was not released until decades later in 1905 as the third movement of Debussy's acclaimed 'Suite Bergamasque' [5]. This suite was written explicitly for piano and is not only one of the most well studied piano suites, but also one of the most well studied classical pieces that to some its analysis is cliché. Today Clair de Lune is considered a important work of the impressionist era, but at the time its conception it would have been considered an avant-garde work of an artist who rejected its labeling as impressionist - but who would later be defined as one of the fathers of the movement.

Clair de Lune was written in D-flat major with a 9/8 meter. Debussy specified the tempo as '*andante tres expressif*' - meaning both 'very expressive' and a 'at a walking pace' or 'slow,' he also included the footnote of '*con sordina*' referring to the soft pedal of a piano, leading to a quieter and thinner excitation. At various points in the piece Debussy gives the musician liberty in their playing tempo ('*tempo rubato*'), while in others directing the musician to slow down and already soft tune ('*un poco mosso*'), or even dramatically fade away in to the ether ('*morendo jusqu'à la fin*').

A Perceptual 'Musical' Analysis

In trying to make musical sense of this movement I sought to break it down into phrasing, and thus identified three major sections: the initial call, a response, then a finale where the two are stylistically met in unison. From my understanding of it, this piece has what most resembles **ternary form**, 'A - B - A+coda', where the final section is thematically dramatized to a close.

The first eight bars feel like a soft introduction to overall theme of 'Section A,' a monophonic texture outlining what is to come. Bars 8-15 are a reiteration of the theme found in the first phrase yet this time with a subtle harmonic buttressing. Bars 15-19 dramatically shift the texture of the piece to include the first signs of parallel motion (melody and harmony rising or falling in unison), which will reoccur throughout the piece, and continue until bar 25.

Bars 25 & 26 are in some sorts an announcement to the change of sections away from 'A' and onto 'B'. The piece rolls in ascension from F to A-flat to D-flat across two octaves, then from E to A-flat, again from E-flat to A-flat, then lastly from A-flat to A-flat - all across two octaves, setting the stage for the minor dissonances to come.

Starting in bar 27, section 'B' introduces rolling harmonic arpeggios in the aforementioned mode of parallel motion. The 'response' to first sections' 'call' has begun, and from this point onwards, movement increases dramatically (as note duration decreases) such that time seems to pass much more quickly than in section 'A', as there is seemingly less silence to reconcile. By the time bar 35 rolls around the piece is repeating the 'response theme' found in the first few bars of section B, although this time in a higher octave, but after 6 bars is steadily making its way down to the original octave in which section 'B' started. During this scale descent there is no great build up to a grandiose or audacious compositional revelation, but rather a subtle harmonic climax (at bar 38), followed by a melodic climax (at bar 41) in which the descent then becomes characterized by even shorter note durations, after which section 'B' comes to a relatively sudden close with a short ascent, and the reiteration of section 'A' begins (bar 51), albeit with with some nuances (thus the coda).

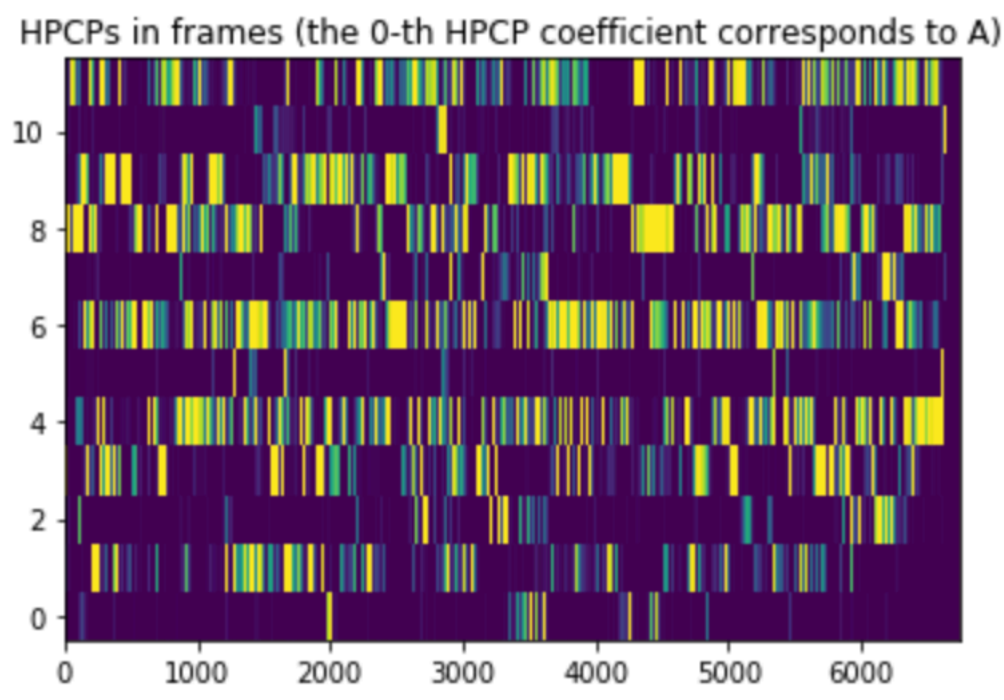
In the third, and shortest section of this piece, the original theme is brought to the forefront however this time around it includes remnants from section 'B', such as the rolling arpeggios and parallel movement as ornamentation to the thematics. Again as in the first section notes are separated such that there is much more silence between them only to be filled by the reverberance of piano excitation. By bar 66 section B's influence is apparent and at the forefront of the acoustic scene. Arpeggios ascend upwards to a close and the piece ends out on a chord asserting the D-flat major key.

Extracted Feature Analysis

Looking at the feature based representation of Clair de Lune I hoped to glean some insights to the piece that pure listening alone had not elucidated. Using Essentia's built-in "Music Extractor," I derived the low-level, tonal, and rhythmic features.

The rhythmic features were by and large useless for help in better understanding Clair de Lune. The analyzed performance of this piece was a recording of pianist Francois-Joel Thiollier who takes ample creative liberty and stretches the length of the performance to his liking (5 minutes and 13 seconds compared to the MIDI performance of the score in “perfect time” that lasted only 4 minutes and 10 seconds). Further, the algorithms powering Essentia’s rhythm extractor are predicated on a committee of eight onset detection functions [6] that serve to inform a beat period estimator and tracking model. Needless to say the high variance from performance to performance of this piece can greatly undermine the consistency of this algorithm, and thus I chose to disregard these features for further analysis.

From the tonal features we can derive the Harmonic Pitch Class Profile (or HPCP), a metric representing the relative intensity of each pitch class. Essentia uses three different HPCP profiles for key and scale estimations: **edma** described as *“automatic profiles extracted from a corpus of electronic dance music,”* **Krumhansl** described as *“reference key profiles after cognitive experiments with users, should work well with pop music,”* and lastly **Temperley** described as *“key profiles extracted from corpus analysis of euroclassical music”* [3]. Considering that the edma and Krumhansl algorithms have specifications for electronic dance music and pop respectively, it seemed wise to move forward taking credence only from the Temperley key and scale estimation algorithm, one whose specification refers to the exact genre of music this analysis pertains to.



Essentia also has the capability of chord detection over time (by streaming the track and analyzing the individual pitch class profiles at a given time-space) to provide another means of key and scale estimation. A quick investigation into the mathematical means by which this is accomplished shows the foundation of it is built upon the aforementioned Temperley algorithm [3]. Accurately this algorithm identified the overarching key as C sharp (or D flat) in the major scale.

Other tonal metrics include **chordsNumberRate** - the ratio of different chords from the total number of chords in the progression, and **chordsChangesRate -** the rate at which chords change in the progression [3]. The raw values of these metrics provide no immediate insights for this analysis, however in the context of looking at many of Debussy's works, or perhaps any comparative task, these metrics might offer a bit more information when their values are juxtaposed against other musical pieces.

Looking at the low-level metrics I chose to consider **spectral energy**, **spectral rolloff**, **dissonance**, and **pitch salience** as relevant. Spectral energy is a measurement of energy across four frequency bands delineated as follows: **low** (20Hz - 150Hz), **middle-low** (150Hz - 800Hz), **middle-high** (800Hz - 4kHz), and **high** (4kHz - 20kHz). Of the four tiers of energy bands the "middle-low" band contained relatively the highest mean value. At .0096 the middle-low band contains nearly 10 times the energy of the next highest energy band mean value, middle-high, with a raw score of .00098. The low frequency range energy band placed third with a mean energy value of .0005, nearly half of the middle-low mean. Lastly the high frequency range energy band mean energy value is the closest to zero at 1.66e-07. With the majority of the energy identified in the Thiollier performance to be between 150Hz and 800Hz we can look to the spectral rolloff feature to find a more specific critical frequency bandwidth between Essentia's delineated energy bands.

Spectral rolloff is the frequency under which 85% of the total energy is contained, and is a good indicator of where, in terms of frequency range, the majority of the piece takes place. In this recording of Clair de Lune being performed, the spectral rolloff frequency was identified at 840 Hz (839.59 to be exact). At just 40Hz over the upper bound of the previously mentioned "middle-low" energy band we can say that nearly the entire piece virtually exists within this adjusted middle-low frequency range (150-840Hz). Further, 840 Hz most closely corresponds to detuned fifth octave G#. A quick glance to the MIDI score confirms that there are only three notes higher than a G#5 played over the course of Clair de Lune.

Dissonance in this context is a measure of perceptual sensory dissonance (not the literal dissonance discussed in music theory), based off a nearly half century old experiment that identified the critical bandwidths between perceptive consonance and dissonance between tonal intervals [4]. Essentia's scoring of dissonance falls between 0 and 1, where 0 is complete consonance while 1 indicates complete dissonance. Interestingly the dissonance mean has a value of .34 with a standard deviation of .081, indicating even if one were to take a frame of audio with an outlier dissonance value three standard deviations below the mean, dissonance would still exist, albeit at a low level, but exist nonetheless.

Pitch salience was designed, as Essentia's documentation describes it, *"as a quick measure of tone sensation."* The author from which this algorithm is based states that the resulting value, a ratio between the amplitude of the highest peak (calculated using an autocorrelation function) and the total power of the signal, is 1 for harmonic sounds and close to 0 for non-harmonic sounds [2]. The Thiollier performance of Clair de Lune scored an average of .545 of pitch salience across the the recording, with a standard deviation of .135, indicating that on average, more often than not, harmonics are salient throughout the piece.

Midi Analysis

Because of my deficiencies in reading music notation and inability to identify both chords or keys through listening alone, I sought to augment my understanding of Clair de Lune using the MIT developed tool **music21**. Doing so allowed me to not only identify the various chords Debussy used, but also uncover the key modulations throughout the piece. In order for music21 to accurately analyze the score, the provided midi file had to first be converted to "musicxml" format using a conversion tool [more powerful than what music21 could offer] such as Finale or MuseScore.

Using music21's 'Chordify' [1] feature, I reduced the complexity of the score into a succession of chords representing the scores' changes over time. Once the score was broken down into chords, I counted up each chord used and analyzed the key of each of the 72 measures, thus showing how Debussy modulated keys throughout the piece. Outside of playing single notes, in Clair de Lune Debussy uses these 10 chords most often: interval class 3 (61), major triad (50), interval class 5 (49), interval class 4 (48), minor triad (34), interval class 2 (30), minor seventh chord (16), incomplete dominant-seventh chord (14), dominant seventh chord (12), quartal tetramirror (10).

Across the 72 measures there are 10 different keys used (number in parens indicates quantity of measures in that key): C# major (21), e- minor (18) , b- minor (9), F# major (7), A- major (5), c# minor (4), f# minor (4), B major (2), E- major (1), f minor (1). While the top 10 modulations between measures were as follows:

Starting Key	Destination Key	Frequency of Modulation
F# major	e- minor	4
b- minor	A- major	3
e- minor	C# major	3
C# major	F# major	3
F# major	C# major:	3
C# major	b- minor	3
e- minor	F# major	3
C# major	c# minor:	3

Unfortunately music21's corpus did not include *any* pieces of work composed by Debussy thus a comparative analysis of his compositional nuances, through the lens of midi and musicxml formats, was not readily available.

Takeaways
As identified through the audio features, the vast majority of the piece falls within the 150Hz to 840Hz frequency range. While this piece was written for the piano, which on a full range has the capability to reach just above 4KHz (around C8), I believe the avoidance of higher octaves helps contribute to the mellow and subdued yet nostalgic feeling that is so commonly evoked by this piece.

Although 'Clair de Lune' is written in D-flat major, Debussy seems to have made an effort to work around traditional chord patterns such that the piece never feels secure in its stated key, leaving room for ambiguity and interpretation. Given my lack of experience with music theory I was not able to hear this upon first listening, however the midi analysis showed the extraordinary amount of key modulation from measure to measure, with only 29% (21/72) of the piece staying in the given D-flat major. It seems as if it is not until the very last bar (72) where Debussy asserts the key by playing a D-flat major chord,

Another interesting take away from 'Clair de Lune' is that while the piece is explicitly written in a 9/8 compound triple meter, strict rhythm does not seem to matter much at all. This lack of distinct rhythm can be found where melodies spill over from bar to bar, blurring their boundaries. This sort of artistic freedom, straying from the norm, is all so very emblematic of the modern era impressionist period from which Debussy is known to be associated with. I feel the most important realization from this sort of perceptual musical understanding is the embrace of ambiguity Clair de Lune demonstrates, both in terms of its melodic and temporal fronts.

Potential Applications
Given the extracted features and information derived from midi analysis, one could imagine a system that could emulate some of the compositional tools Debussy used in making Clair de Lune. One that composes harmony and melody in parallel motion, dancing around the root and dominant scale degrees of a key by way of modulation, conveying constant ambiguity in that it never anchors in acoustic positioning, only to return and assert its key and scale at the end. The gathered data might lend itself well to be embodied by a Hidden Markov Model or Support Vector Machine in terms of algorithmic output. However reconciling both the lack of strict rhythmic structure, and the performative freedoms humans are accustomed to, would be perhaps present the largest roadblock to deeming this system a success.

Reference

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