AN ORGANIC SYSTEM FOR TONAL COMPOSITION
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ABSTRACT
This paper aims to discuss and question the separation between computational musicology research involving tonal musics, and the creative composition and generation of tonal musics. It considers how style modelling and synthesis relate to creative pursuits, and the problems in applying principles from computational musicology to creative purposes. Potential hurdles in this relationship include a pervasive reluctance to recognise computer-created works as genuinely creative, as well as the musical specificity required by analytical style-modelling. I argue that there is a teleological aesthetic difference between computational creativity and compositional creativity, which affects the perception of a composed work as being "creative". The crucial difference between these paradigms is the agency of the (human) composer within the creative process. The author's own composing system, Deviate, is described briefly and evaluated in regard to these issues.

1. INTRODUCTION
Computational musicology, analytical musicology, and music psychology offer unique insights into how musics are composed, performed, and interpreted. Research in these areas includes such areas as sound (the perception of pitch and timbre), general musical rules relating to pitch and rhythm, as well as style-specific analyses. This exploration of the constructions of tonal musics can be traced back to the development of rules for counterpoint, serialism, Meyer's theories of expectation (1956), Schenkerian analysis, and subsequent analytical models (Narmour, 1977).

1.1. Music analysis, psychology, and computation
A substantial portion of research in these areas has occurred over two decades ago, and many current studies still rely on these seminal texts. These include tonal hierarchies (Krumhansl 1979, 1990), grammatical hierarchies of structure and rhythm (Lerdahl and Jackendoff, 1983), improvisational performance analysis (Pressing, 1987) and consonance and musical style (Cope, 1991). More recent studies include music, expectation and emotion (Huron, 2006) and musical probability (Temperley, 2007). Style-specific analyses and modelling have been undertaken in a variety of areas, from Kippen and Bel's work with tabla drumming (1995) to Collins' generation of breakbeat patterns (2002).

1.2. Creative generation of tonal musics
These analyses are, however, seldom applied for practical or creative purposes. Meredith (1996: 5) writes, "Only a small number of programs have been developed for the purpose of automatically generating tonal music" (italics in original). He cites Ebcioglu's assertion (1992: 327) that musically trained composers typically do not consider tonal music a priority, and "typically the musically trained avant-garde composers who use computers for algorithmic composition do not consider tonal music important, and those computer enthusiasts who do have an interest in algorithmic tonal music composition are not musically trained" (cited in Meredith, 1996).

The relationship between computers and music is well explored in a practical sense, whether for synthesis, information retrieval, sound recording, or music production. Meanwhile, creative generation of tonal musics is still relatively rare, as stated above, despite the substantial research into this area for musicological purposes. In this paper, I will consider the relationship of these fields—computational musicology, analytical musicology, and music psychology (henceforth referred to under the umbrella term of computational musicology for brevity)—to composition and creative musical applications.

1.3. Broad, modular, and organic systems for tonal composition
This paper discusses the development of "organic" music systems, where general musical rules can be recombined with different parameters to generate creative works with variety and customisability, rather than pastiches produced by empirical style modelling. It is proposed that combining broad, rather than specific, musical rules permits more creative applications for generating tonal musics. This will be discussed with regard to the author's own experiments.

2. MUSICOLOGY, COMPUTATIONAL MUSICOLOGY, AND COMPOSITION

2.1. Musicology and computation
The relationship between musical analysis and computation is complicated. From a musicology perspective, Cook (2005) argues that musicologists have yet to engage fully with the potential that computation...
affords, in part because traditional musicology is oriented primarily towards the study of scores (ibid: 3) which have well-established (non-computational) analysis methods. Crawford (2010) likewise states, “For many years I have been an optimist about what computers can do for the musicologist, but, to be honest, little of what I hoped for when I started has yet come about”. These statements identify the difficulties inherent in quantitative analysis of music, and express concern that many areas are under-explored. Nonetheless, some useful discoveries, cited in the Introduction, have been made, which have been used computationally in empirical musicology, style synthesis, and composition.

2.2. Computation and composition

The relationship of computational music analysis to creative composition is likewise unclear. Describing the four major types of automated composition, Pearce et al (2002) identify the following: algorithmic composition, the design of compositional tools, the computational modelling of musical styles and the computational modelling of music cognition (ibid: 119). This indicates a persistent divide between the first two categories as creative endeavours, and the second two as research-oriented pursuits.

Although algorithmic and generative composition are recurring in music ranging from serialism to granular synthesis, the use of analysis-derived processes in tonal composition still appears to be relatively uncommon (see Efchogiou, 1992: 327). Some potential reasons for the rift between creative computer-based composition and computational musicology are proposed below.

3. SPECIFICITY VERSUS BROADNESS

3.1. Style modelling and creativity

Robust and complex generative grammars, such as Cope’s Experiments in Musical Intelligence (1996) have demonstrated that convincing works can be created based on an existing style and corpus of material. Although such corpus-based systems can reliably generate musical material of a particular style, the output is necessarily confined by the limits of that style. Furthermore, music such as Western classical and jazz are often bound by prescriptive rules relating to melodic contour, cadence, and voice leading. This makes creative generation (rather than style modelling) of these musics more difficult. Strasbeka by Anders (2007) is one example of a “generalised” music generation/representation system, which permits recombination of constraint parameters to generate music including Fuksian and florid counterpart; this application, however, requires fairly extensive rule specification and processing (ibid: 164).

3.2. Broad approaches to creative generation

A broader, non-style-specific approach to musical generation means that many prescriptive rules are approximated or disregarded in favour of more general rules for rhythm, pitch spaces, and so on. By focusing on what might be generally called “popular” music styles, the composer (or user) can generate more diverse musical results. One problem with this ‘broad’ approach is that it is much more difficult to assess computational or musical success, as firstly there is no single style similarity as a goal. Processes and parameters are more difficult to derive through quantitative analysis of a musical corpus. Because the output of a broad system is, by design, variable, qualitative and quantitative analysis of the system’s output is similarly problematic. Furthermore, attempting to create original, new compositions involves intentional overgeneration (after Meredith, 1996: 10), that is, producing material beyond the foreseen capabilities of the system. This results in (aesthetic) variability of musical output.

4. THE CREATIVITY PROBLEM

Another issue with the creative application of computational musicology relates to creativity. Style synthesis of tonal musics can vastly contain elements of pastiche which are contrary to the modernist and avant-garde prerogatives to innovate. This is relevant to the broadness issue discussed above, but is also defined in “moral” terms; can a tonal work created by a computer be considered creative?

4.1. Computer creativity and composer creativity

To answer this, it is necessary to distinguish computer-creativity from composer-creativity. Jordanou’s (2011) research defines computational creativity as the ability of a system to produce quality output that is also varied and novel (ibid: 1). However, Jordanou also recognises that “a creative practitioner’s primary aim [...] is to produce creative work, rather than to critically investigate creativity”. This positions computational creativity as a process of critical investigation, rather than one focused on the act of creative composition. In other words, while a musical system may create, this does not necessarily imply a creative act on the part of the composer; and consequently, if composer-creativity is not present, the artistic merit of the work is compromised.

The friction between these two types of creativity is highlighted by critical reactions to David Cope’s Emily Howell project. Although Howell’s work was occasionally well-received, there is a reluctance to recognise heavily machine-mediated composition (and the exaggerated depictions of Emily Howell as an independent composing entity) as genuinely creative, that is, as “original” or “artistic”, rather than “clever”. As music critic Mark Lawson states, “A computer, cleverly programmed, could probably produce the Doubtful Thomas Passion by JS Bach or More Snow on Kilimanjaro by Ernest Hemingway. But the exercise would be worthless because the works from the software would not be informed by being a God-fearing kapelmeister in 18th-century Germany or a suicidal macho male in mid-20th century America.” (Lawson, 2009). This antipathy towards recognising a computer as genuinely (rather than computationally) creative, in regard to Cope’s research and composition, is extensively covered by Hofstadter and others (1996).
4.2. Creativity as a “human” pursuit

The Emily Howell paradigm represents an extreme example of how composers, as opposed to researchers, work with computers, in that it (admittedly somewhat inaccurately) positions the computer as the sole composer. Although reactions to Emily Howell insisting that the composer’s intention and prorogative is crucial to the quality of the composed work may seem old-fashioned, the rationale of an artistic work is crucial even in seemingly progressive musical contexts, as evidenced by the importance of program notes. Even though a musical composition, if created by a computer program developed by a (human) composer, is logically the work of the composer, it is argued that a difference is perceived. This is specifically the case for generative and algorithmic composition of tonal music, where style synthesis complicates the composition of original works.

5. AGENCY

The above example does not mean to suggest that automated composition of tonal music is necessarily without artistic merit for the composer. However, agency is critical in determining how the aesthetic significance of the musical work is evaluated. This notion will be explored in regard to two primary creative fields within computational musicology of tonal music: accompaniment/improvisation systems and live coding.

5.1. Accompaniment and improvisation systems

Score-based accompaniment systems need to engage with aspects of musical rhythm, pitch, and timing in order to recognise input from the primary musician; this involves pitch, beat, and pattern recognition to effectively follow a score (Daanen and Raphael, 2006). Accompaniment systems which improvise to a musician’s input likewise monitor acoustic (or other musical) input, but generate new, rather than predetermined, output in response. The contexts of these improvisation systems are for the most part tonal, and commonly based around jazz. Such systems (including Rowe’s Cypher (1993), Thom’s Band-OUT-of-a-Box (2001) and Pachet’s Continuator (2003)) employ musical grammars, recombination, and probability tables, techniques common to style synthesis.

5.2. Live coding

Live coding is more difficult to precisely define, as given the ephemeral nature of live coding, few examples of code exist (see Collins et al., 2003); furthermore, there is little commonality of musical style, aside from perhaps a general trend towards contemporary electronic music. Although many live coding performers engage with timbre, granular processes, and samples, a number also deal directly with tonal note generation as well (Brown and Sorenson, 2009). The situation of live coding as a primarily performance-based pursuit engenders the building of musical structures from scratch, and can involve probability routines, recursion, and defining pitch spaces.

In both these circumstances, the agency of a performer (as composer) is key. While style synthesis assumes a minimal amount of creativity (as opposed to research input) by the composer, both accompaniment/improvisation systems and live coding require a real-time creative agent in order to operate. The condition of creative agency is thus fulfilled by the performing musician/composer or the real-time ‘operator’ of the system, rather than by the system itself or by its designer. The following section will discuss further applications of agency in creative computation of tonal music.

6. ‘ORGANIC’ SYSTEMS FOR GENERATING TONAL MUSIC

6.1. Defining ‘organic’

It appears that the creative application of generative tonal musical systems is limited by the specificity inherent in style synthesis, by a focus on computational rather than compositional creativity, and by the issue of compositional agency. Using the fifth definition of ‘organic’ in Collins’ English Dictionary (online), “made up of many different parts which contribute to the way in which the whole society or structure works, an organic whole”, it is proposed that an ‘organic’ musical system can be used for creatively generating tonal music. This involves interlinking different musical processes and parameters to create a variety of musical results, rather than to model a specific musical style.

6.2. Commercial precedents

SSEYIO’s Koan (now known as Noatikl, MixTikl, and several other programs) (Intermorphic, 2011) is probably the most well-known system for broad, non-style-specific generation of tonal music. Similarly, musical ‘games’ for generative tonal composition are plentiful; see Eno and Chillers’ Bloom application for iPhone (2008), or Wolfram Alpha’s WolframTones music generator (2011), which uses cellular automata to generate music spanning several styles. These however appear to be mainly for gaming or recreational purposes, rather than for composition as such. The lack of use of systems such as these for composition may be attributed to several factors; oversimplicity, limited customisability for the user, lack of quality control, limited context-awareness, and restricted directability. As third-party products, these programs do not permit the necessary creative agency for the composer.

A recent review of Apple’s GarageBand application for iPad clearly illustrates the problems (and also the advantages) of increasing computational creativity at the expense of composer creativity. This easy-to-use version of GarageBand incorporates some very basic generative features, including changeable note densities for drum loops, arpeggiation, and key-limited pitch spaces. The reviewer writes, “No musical talent?
No problem", and, "Even if you can’t play a note, GarageBand for iPad will have you playing and even composing music soon after you first fire it up" (Silverman, 2011).

The approaches discussed so far—style synthesis, accompaniment/improvisation systems and live coding, and commercial applications—represent three different approaches to generating tonal musics, each with particular benefits and drawbacks. Characteristics of style synthesis include musical complexity, specific output, and use of higher-level structures, but limited creative agency. Live coding and accompaniment systems allow more agency, but are primarily performance-based endeavours. Third-party applications can permit generation of musical events across a range of styles, but limited customisability and agency for the end user. The following will consider an organic system for tonal composition based on the author’s research.

7. DEVIAZE (2006–)

Deviate was originally designed as a live improvisation system for contemporary popular electronic music and related loop-based styles as part of the author’s PhD thesis (2010). Unlike improvisational accompaniment systems, it takes computer-based interaction as the only input, and does not perform any sort of signal- or MIDI-based machine listening. Built in Max/MSP, it generates MIDI notes which can be routed to a multi-track sequencer for recording and to VST/AU plug-ins for sound generation. Audio and video examples are accessible online at [website URL].

7.1. Components

Deviate’s components aim to cover fundamental musical processes and features, such as tempo, time signature, rhythmic patterns and pitch spaces. Further controls include note transposition, variation from rhythmic patterns, and variable density and tonality of generated notes, while more mechanical features such as velocity and duration of note events can also be altered.

<table>
<thead>
<tr>
<th>Drums (6 total):</th>
<th>Pitched output (16 total)</th>
<th>Master-level control</th>
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<tr>
<td>Rhythm template selection (10)</td>
<td>Pitch template selection (12)</td>
<td>Tempo</td>
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<tr>
<td>Variation from rhythm</td>
<td>Rhythm template selection (12)</td>
<td>Time signature</td>
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<tr>
<td>Density</td>
<td>Tonality</td>
<td>Swing</td>
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<tr>
<td>Automatic template variation</td>
<td>Density</td>
<td>Playback alteration</td>
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<td>Automatic pattern variation</td>
<td>Tonic note</td>
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<td>Automatic density variation</td>
<td>Chord selection</td>
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<td>Note duration</td>
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<td>Order of playback</td>
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Table 1. List of controllable parameters in Deviate

A central aim in building this system was the ability to generate music in a range of styles, and as such Deviate is built in a modular fashion, where many generators are used to create note events. Generation parameters for each of these modules can be independently selected.

Deviate incorporates features including melodic contour, hypermetric organisation (Huron, 2006: 248), probability-based determination of pitch (Temperley, 2007: 3), reinforcement of tonal centre (Jones, 1993: 76) tonal hierarchies (Krumhansl and Kessler, 1982), and rhythmic grouping (Toussaint, 2005). Up to 22 modules (6 drums and 16 for pitched content) are used to generate musical output, each with parameters that can be independently controlled. A brief list of these parameters is detailed in Table 1.

8. EVALUATING AGENCY

Deviate’s construction, involving modular note generators with individually alterable parameters, has proven to be capable of generating very varied musical output. Its capacity for customisation and user interaction with processes provides substantial room for compositional agency. Furthermore, its construction based on general musical rules, rather than analysis of a musical corpus, allows processes to be independently varied. These loosened constraints extend the applicability of the system.

8.1. Known drawbacks

There are, however, some issues with Deviate’s construction. Its modules and processes are not interdependent, and there is zero context-awareness between modules and in note generation, meaning that processes such as voice-leading are impossible. Because it was developed to be a live system, usable and comprehensible in real-time, it generally lacks complexity and higher-level structures. There is so far no facility for timbral awareness, as only MIDI note data is generated. Lastly, given the ‘broad’ nature of this system, it does not always generate musical output that is consonant or aesthetically pleasing, although it is certainly capable of doing so.

8.2. Advantages

It is possible that these drawbacks are, to an extent, a key part of its application as a creative composing system. A system capable of robustly generating musical output would suggest that it possesses sufficient ‘computational creativity’, thereby diminishing the agency of the composer. This would also imply that many musical rules and processes are in operation, as well as higher-level rules determining aspects such as aesthetics and musical form. This in turn may make meaningful and comprehensible compositional agency within such a system difficult.

8.3. Areas for future research

Still, many improvements are possible. Firstly, further testing of rhythmic and pitch templates could improve musical output. These templates could be designed via a genetic algorithm process. Secondly, interface and control elements could be improved through detailed recording and analysis of performance. A final area for
investigation is the incorporation of a limited amount of inter-module awareness for more consonant polyphonic output, although this may come at a trade-off for compositional agency.

9. CONCLUSION

The question of user agency is important in considering the application of findings and techniques from computational musicology in composition. A system for creative composition must permit sufficient compositional agency in order to be used creatively. Style synthesis, although it generates high quality musical results, often does not allow agency because it is tailored to specific ends and its rules are highly complex, often requiring analyses of an existing corpus. Live coding and accompaniment/improvisation systems necessarily allow creative agency as they incorporate a performative aspect. Finally, commercial applications are often aimed at a “game-like” rather than a creative use of music generation, and can suffer from lack of musical complexity, customisability and agency for the composer, where a lack of musical talent becomes irrelevant (Silverman, 2011).

Agency is ultimately dependent on the system's complexity and flexibility; the issues discussed support a modular, organic approach, which exponentially increases the range of musical results and permits a high level of engagement and agency for the composer. It is proposed that there is a trade-off between computational creativity and compositional creativity, and that a successful system for generative tonal composition must balance both these aspects.

10. REFERENCES


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