ISEA2015
Proceedings of the 21st International Symposium on Electronic Art
ISSN: 2451-8611
ISBN: 978-1-910172-00-1

A Composer's Search for Creativity Within Computational Style Modeling

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Abstract

Computational style modeling involves building a computational representation of the surface of musical works, one that captures features of rhythm, melody, harmony, and structure within its patterns. While such models are useful for musicological purposes, the creative use of these models to generate new music consistent within a given style raises a critical question: can generative music based upon a corpus be considered creative? This paper addresses this question, examining how creativity has been historically viewed, and discusses recent research into creativity. Examples of computational creativity by the author using both rule-based and corpus-based systems will be discussed.

Keywords

Creativity, computational creativity, generative art, style imitation, David Cope, Experiments in Musical Intelligence, postmodernism.

Introduction

One of the most basic tenets of creativity is *originality*, in which something *novel* – an object, idea, or solution that has not previously existed – is created [1]. A secondary aspect of creativity is the notion of value, or worth; specifically, the creative product must be regarded as having some *usefulness*. Subjectivity is thus part of the equation, which explains why the relative balance between innovation and craft has shifted throughout history. While some creators, such as Haydn, have been acknowledged for generating many of the forms and ensembles that we now associate with the classical era in music (approximately 1760-1810), his contemporary Mozart, who created no new forms, ensembles, or styles, is venerated as one of the greatest composers of all time. Haydn *transformed* his musical space, whereas Mozart remained firmly within it; his specific creativity is found within the content rather than its structure [2].

In applying notions of creativity to machine-generated artifacts, we confront other concerns. Anglo-American copyright law requires a work to be sufficiently "original" to warrant copyright protection; however, originally does not refer to historical novelty, but to human origin: works produced by mechanical processes without any contribution by human author are not registrable [3]. How then, does one assess creativity within works generated by computer? Researchers within the nascent field of computational creativity – who aim to endow machines with creative behavior – have avoided the thorny distinctions involving distinctly human processes [4] by defining computational creativity self-referentially as "the performance of tasks which, if performed by a human, would be deemed creative" [5].

Early attempts at incorporating computation into artistic production tended to be expert systems designed by practitioners to follow heuristic rules generated by its creator [6]; despite AARON's ability to produce a stylistically consistent body of work that, by Wiggins' definition, was creative, its creator refused to be drawn into the question of whether his system was, in fact, *creating*. In retrospect, one can view AARON as a machine that reflected Cohen's taste and aesthetic; it was completely bound by rules set by its creator in order to produce output that Cohen felt artistically desirable.

At roughly the same point in time, Cope was exploring similar issues within music, albeit using different methods. Instead of determining the rules of the system beforehand, Cope's system analyzed a body of music in order to extract the necessary rules for generation [7]. By curating a consistent corpus for such machine-learning, Cope avoided generality in the derived rules, and was able to produce music that was stylistically consistent within the corpus; for listeners, it meant that he was able to generate music that, even to expert ears, *sounded* like Mozart (for example), but music that Mozart never actually composed. In discovering the distinctive and recognizable characteristics within the corpus, Cope's system essentially extracted its stylistic elements [8]; in using those features to generate new music, the system can be considered *style-imitative*.

A standard argument against art generated using a corpus is that the system is incapable of producing novelty, and can only reproduce what is already in the corpus. This paper will address this question, examining how creativity has been historically addressed, and discussing new research into creativity. A brief reexamination of Cope's work and its detractors will follow. Finally, examples of computational creativity by the author using both rule-based and corpus-based systems will be discussed.

Originality and Historical Perspective

At different points in history, the relative novelty of an

item has had different value. For example, in the twentieth century, due to its predominately modernist aesthetic, the uniqueness of an item, especially an artwork, was paramount: no worse allegation could be leveled at a work than for it to be declared derivative. According to Gregory, such concerns of originality developed out of European Romanticism [9], beginning in the Eighteenth century [10]; prior to this time, audiences favoured variations on familiar ideas and themes, rather than novel ones [11].

The reuse of existing material was commonplace at various points in musical history. The origins of polyphonic music in Europe can be found in the use of a *cantus firmus*, in which novel melodies were combined with existing sacred melodies [12]. This type of derivative composition continued for over 500 years, and expanded into the parody, or imitation, mass of the 16th century, which combined multiple voices of pre-existing compositions: Palestrina wrote over 50 such works [13]. By the 1600s, composers began to abandon their dependence upon existing sacred melodies in order to explore genuinely novel melodic features: it is no coincidence that the Western notion of creativity first appeared during this time of the Renaissance [14].

However, even by the late Baroque period, genuine novelty was never assured, nor, it seems, desired. J. S. Bach's earliest work, two volumes of keyboard works published in 1731 as his Opus 1, are clear imitations of the music of his immediate predecessor at Leipzig, Johann Kuhnau. Of course, young artists, even in the 20th century, are given some leeway in their search for novelty: Stravinsky, an innovative force in 20th century music, borrowed heavily from the music of his teacher, Rimsky-Korsakov, in his early works prior to 1910 [15]. However, while Stravinsky went on to compose *Le Sacre du Printemps* – one of the most innovative works of the century – a few years later [16], Bach's continued "borrowing" of existing music was not considered questionable: his *Mass in B Minor* consisted of movements from his earlier cantatas, while his *Concerto for four harpsichord*s BWV 1065 was a direct re-workings of Vivaldi's *Concerto for 4 violins* RV 580.

By the 19th century, the desire for originality, as typified by the persona of Beethoven, was solidified during the Romantic period. Some researchers equate Beethoven's perceived creativity with his deafness, suggesting, as Ludwig's brother Karl does, that his inability to hear other's music forced him in directions other than imitation [17].

The 20th century was dominated by the tenet of modernism, and its rejection of historical reference [18], even to oneself; as a result, serial composers were compelled to generate a new grammar with each composition. Stravinsky's dip into history through quotation and reference, beginning with *Pulcinella* (1920) remains an example of modernism, rather than post-modernism, due to the irony inherent within his brand of neo-classicism [19]. While the aforementioned work based upon Pergolesi (1710-36) may suggest a post-modernist sentiment through its direct quotation of the original, his subsequent works within the style – beginning with *Octet* (1923) – managed to reference earlier stylistic periods without quotation. As such, he was able to remain a modernist through his ability to use earlier stylistic material in search of novelty, rather than juxtaposition.

Postmodernism's questioning of originality and meaning had very specific interpretations in contemporary music, as discussed in the next section. Barthes' argument against authorial meaning [20], for example, had little direct influence upon music, which itself was questioning whether music had any meaning at all [21]. The exploration of appropriation and its questioning of originality in the work of visual artists such as Duchamp, Warhol, and Levine eventually did find parallels within music in Oswald, Zorn, and Schnittke's compositions, for example. Similarly, sampling culture in Hiphop, and even soundscape composition's direct recording of the environment can be argued to question originality.

Stylistic Appropriation

In the 1960s, American composer George Rochberg abandoned modernism's forge for uniqueness and began to compose directly within an earlier style, basing individual movements upon the styles of specific composers [22]. Rochberg argued in opposition to the teleological view of music, stating earlier styles remain relevant, and free for appropriation:

> "the twentieth century has pointed – however reluctant we may be to accept it in all areas of life, social as well as political, cultural, as well as intellectual – toward a difficult-to-define pluralism, a world of new mixtures and combinations of everything we have inherited from the past and we individually or collectively value in the inventions of our own present, replete with juxtapositions of opposites (or seeming opposites) and contraries." [23]

Like Stravinsky, Rochberg had a deep love of the past; however, Rochberg was not prepared to view the past through the lens of modernity, and chose to fully inundate himself in style imitation: his String Quartet No. 5 (1978)[1] did not merely quote Beethoven, but introduces novel material and develops it completely in the style of the Romantic composer. This did not ingratiate him with critics, some of whom questioned whether his music was even "valid" or contained any artistic statement [24]:

> "Rochberg exhibits no novelty of his own as imitator, for the more successful he is in that role, the more successfully Rochberg is lost as a creator. He cannot have a faithful copy if there are any of his own perceptions present. It is a no win, "catch-22" aesthetic principle, of which Rochberg's work is living proof: art cannot be only imitation. Even if the artist chooses to use another's material, it must bear his own unique stamp."[24]

Block was writing in the early 1980s, a time when modernism in music was no longer the dominant paradigm; instead, tonality – a overarching goal of Rochberg's aes-

[1] An example recording on YouTube: http://youtu.be/D-snNWzq9G0

thetic – was beginning to reassert itself as the principal vocabulary of post-modernism. This may explain Block's contextualization of his criticisms:

> "What is therefore objectionable in George Rochberg's music is not his tonality, not his eclectic mixtures of styles nor his desire to capitalize on the beauty of the great masters' perceptions and material but his necessarily unsuccessful attempt to totally recapture a spirit that is not his own and to which he adds nothing." [24]

Not all critics were as hostile: Ringer's detailed analysis of Rochberg's music lead him to state that the sophistication of the procedures used by the composer were far more original than the purely novel ones used by many of his contemporaries [25]. Thus, we have a dichotomy of viewpoints: Block argues for novelty, while Ringer suggests novelty alone does not engender creativity.

Cultural Appropriation

Stylistic appropriation within music was never limited to extant European styles: referencing non-Western music – whether Mozart's use of Turkish Janissary music in his *Rondo alla Turca* or Stravinsky's use of Russian folk melodies in *Le Sacre du Printemps* – was fashionable, if exotic. Reich, in his *Writing About Music*, advocates for the potential of non-western art forms to permeate western aesthetic creative processes:

> One can create a music with [one's] own sound that is constructed in the light of one's knowledge of non-Western *structures*…This brings about the interesting situation of the non-Western influence being there in the thinking, but not in the sound… Instead of imitation, the influence of non-Western musical structures on the thinking of a Western composer is likely to produce something genuinely new. [26]

Creativity Research

While artists have an intuitive understanding of what it means to be "creative", relatively recent scholarly interest into creativity from a variety of disciplines – including psychology, cognitive science, education, linguistics, philosophy, and computer science – have produced more formal definitions. Most definitions include novelty [27] and appropriateness [28], while others include a requirement for culture from within which creative actions are possible [29, 30]. A few additional points from creativity research will prove useful for our discussion.

Psychologist Margret Boden distinguishes between two types of creativity, P-creativity and H-creativity [31]. The former, also referred to as psychological creativity, implies that the object or idea is novel to the individual alone, while the latter, also referred to as historical creativity, implies that the object or ideas is novel to society as a whole. The separation of eminent creativity from more everyday creativity can be found in Kaufman and Beghetto's notion of the Four C model of Creativity [32]: the highest level – *Big C* – involves creativity that is considered "great" in a given field, *Pro-C* is creativity exhibited by professionals within a field, although not considered eminent, and the remaining two everyday creative acts fall into variants of *little-c* creativity.

Boden also introduces the notion of *conceptual spaces:* a set of *concepts* that are deemed to be acceptable as examples of whatever is being created [33]. In regards to these spaces, *exploratory creativity* is the process of exploring within a given conceptual space, while *transformational creativity* is the process of changing the rules delimiting the conceptual space. Thus, *Pro-C* artists accomplish exploratory creativity, while only *Big-C* artists are able to accomplish transformational creativity.

Previous Research in Style Modeling

Using machine-learning for style modeling has been researched previously. Dubnov *et al.* [34] suggest that statistical approaches to style modeling "capture some of the statistical redundancies without explicitly modeling the higher-level abstractions", which allow for the possibility of generating "new instances of musical sequences that reflect an explicit musical style". However, their goals were more general in that composition was only one of many possible suggested outcomes from their initial work. Their examples utilized various monophonic corpora, ranging from "early Renaissance and baroque music to hard-bop jazz", and while they do state their research produced two original computer-assisted compositions performed by the French Orchestre National de Jazz, no specific information is provided regarding these works.

The concept of style extraction for reasons other than artistic creation has been researched more recently by Collins [35], who tentatively suggested that, given the state of current research, it *may* be possible to successfully generate compositions within a style, given an existing database.

Unfortunately, space does not permit a full discussion of computational production systems that have explored stylistic modeling; suffice to say, it does have a long history, especially if one considers any system that is stylistically consistent. For example, Lewis' *Voyager*, an interactive expert system based upon rules provided by the composer that dates from the 1980s, produces free jazz improvisations in the specific North American tradition [36]. While Lewis argues that machine agency challenges outmoded human-centric notions of expression, he also notes that *Voyager*'s use of simple randomness, the primary factor in his system sounding non-human, results from practical necessities [36], a decision my own systems have attempted to avoid [37]. It should be noted that many composers utilizing machine-learning on a corpus do so not to replicate the style of the corpus for aesthetic reasons; instead, we do so for a more practical purpose in deriving generative rules from exemplars, rather than having to hand-code such rules ourselves.

Artistic Exploration of Style Modeling

As has been already discussed, style imitation is not unique to computation: post-modernism is ripe with stylistic polymorphism [38]; my doctoral thesis described the stylistic appropriation I used in a major work for dance [39]. In that work, my compositional process was decidedly traditional: deciding to base the work on the music of Vivaldi, I immersed myself in his music, albeit audio recordings. When it came time writing the actual music, I was able to replicate the surface features of the music – its melodic types, harmonies, figurations; however, few listeners would have mistaken the resulting music as Vivaldi's. Importantly, my deconstructing and reframing of the Italian Baroque style in post-modern terms allowed for the use of material in ways that were not possible in Vivaldi's time.

Similarly, following Reich's incorporation of non-Western influence on Euro-American musical structures, my Master's thesis explored such compositional directions [40]. Many years later, when creating generative computational systems, I returned to notions of appropriation, yet reflective of Reich's approach: basing rhythmic generation on the complexity of Indian *tala* and the rhythmic interaction upon West African drumming [41]. As before, the use of style appropriation was an artistic decision to explore new methods of formal organization: few audience members would have felt they were listening to either Indian, or African, music.

Human conceptual spaces

Underlining the difference between *influence* and *imitation* is important when considering an artist's ability to freely use whatever material at his/her disposal. Despite Block's objection to imitation, Rochberg's composing directly within an earlier style was a logical extension of post-modernism's appropriative cravings. Block fundamentally misunderstands Rochberg's motivation: it is not to seamlessly recreate Beethoven's music, but to posit the potential of an earlier style's appropriateness in temporally disjunct surroundings.

> "The real scandal lay not in Rochberg's rejection of doctrinaire serialism or aleatoric composition, but rather in his far more radical rejection of the whole philosophical foundation of the postwar avant garde. These works were the manifesto of a revolt." [42]

Applying Boden's conceptual spaces model, the "artistic" use of stylistic modeling retains the conceptual space of the artist: by appropriating Beethoven's style, Rochberg *transposed* Beethoven's conceptual space into his own, which remained firmly in the 20th century. Of course, one could also argue that in doing so, Rochberg *transformed* the existing modernistic conceptual style.

Virtual Conceptual Spaces

A problem arises when one considers computer models of style: while using such models for musicological purposes are straightforward [43], what happens when these models are used generatively. Within which conceptual space does the generative work exist?

Hofstadter, like many others, suggests that artistic creation is reserved for humans [44]. In describing what would be required for a computer to create music, he suggests

> "It would have to understand the joy and loneliness of a chilly night wind, the longing for a cherished hand, the inaccessibility of a distant town, the heartbreak and regeneration after a human death. It would have to have known resignation and world-weariness, grief and despair, determination and victory, piety and awe. In it would have had to commingle such opposites as hope and fear, anguish and jubilation, serenity and suspense. Part and parcel of it would have to be a sense of grace, humor, rhythm, a sense of the unexpected – and of course an exquisite awareness of the magic of fresh creation. Therein, and therein only, lie the sources of meaning in music. [44]"

Hofstadter displays a somewhat antiquated, and certainly referentialist view of meaning in music [21], suggesting a rather romantic notion that the emotion a listener feels when listening to music is contained within the music itself, and the result of a composer's direct desire to transmit such feelings. However, his questioning of volition is relevant and insightful: computers lack the desire to create, and therefore lack the ability to create their own conceptual spaces. Therefore, any system that generates music using style modeling could only produce music within the original conceptual space of the corpus.

Hofstadter's comments came in response to Cope's system, Experiments in Musical Intelligence, or EMI [45]. Hofstadter's original reaction to EMI's music accepted their proficiency – suggesting they could be the output of a graduate student in music – but questioned their originality. Such judgments are often leveled against computer-generated music [46], but are unnecessarily biased in this case: Cope's corpora consisted only of exemplars, acknowledged geniuses of music. When one considers that 99% of all music composed is lesser than that of the masters, does that discount all music outside of masterworks? In a social media comment on my own work in musical metacreation, one person wrote: "A computer couldn't write Beethoven's String Quartet 3 in F, plain and simple", seemingly invalidating all music incapable of meeting Beethoven's transformational abilities.

Faced with the output of EMI in the form of extremely accurate stylistic imitation of Chopin, Hofstadter was perplexed that a system based solely upon the analysis of the symbolic representations of the composer's music could create music that was *not* "emotionally empty":

> "I was truly shaken. How could emotional music be coming out of a program that had never heard a note, never lived a moment of life, never had any emotions whatsoever?" [47]

Hofstadter's objection to EMI was that it was a machine capable of producing "human" music. Wiggins – a researcher into computational creativity and artificial intelligence – objects to Cope using too many human methodol-

ogies, labeling it pseudo-science [48], and criticizing Cope for such aspects as selecting individual items from EMI's output for presentation. This last criticism once again places computer-generated music on an unfair pedestal: why is it perfectly normal for artists to select which of their human-composed works to publically present, but not computer-generated?

This treads into the little traversed area of the autonomous virtual artist. The use of software as assistive technology in the service of an artist is perfectly acceptable, as the concept space being explored clearly remains in the hands of the artist. However, affording greater autonomy to the system severs this link, and the concept space seemingly becomes that of the system, which, paradoxically, is incapable of autonomous artistic volition. Since Cope, or anyone else interested in stylistic modeling, is still required to select the corpus, the association between human and system output is retained; as such, the human would seemingly maintain the right to select from the system's output.

The difficulty, of course, is assigning "creativity" to such systems. Computer-generated art may be statistically novel – its specific patterns may never have been previously existent – therefore being H-creative. Artworks created by systems have proven to be valued when compared to human-created artwork: AARON's paintings have been shown in galleries, and EMI's music has been performed by symphony orchestras. While computer-generated art may not, as of yet, have produced *transformative* artworks, few human creators can claim such achievements.

By merging the disciplines of art and creativity together with scientific disciplines of computer science, we risk offending two camps at once. Those in the former field require human experience and expression, while those in the latter require pure objectivity. For example, Wiggins doesn't accept Cope's claim that "what matters most is the music" [49], and counters "with hand-coded rules of whatever kind, we can never get away from the claim that the creativity is coming from the programmer and not the program." [48].

Wiggins' own research into computational creativity is focused upon a search for a scientific solution, eliminating any subjective element from the equation. Wiggins seems to suggest that because art isn't science, its practitioners are incapable of describing what they do, and it is up to science to rectify this shortcoming [50]. He states that a failing of Lerdahl and Jackendoff's Generative Theory of Tonal Music [51] is its inability to be successfully implemented as a generative system without recourse to human knowledge [52]. Whereas Wiggins sees the need for human input as failure, I see it as hope; Wiggins seems to want to eliminate the subjective artist in favour of objective science, while I embrace the continued need for artistic involvement in generative systems [53].

Reflections on Style Modeling

My own creative research has involved creating computational systems that can be used as compositional assistants [54], or as autonomous generators of music [55]. The perception of creativity – whether it is viewed as mine mirrored through the system or possibly the system's itself – has been at the forefront of my thinking.

Earlier systems were based in models of non-western music and required human intervention for performance. For example, in *Bhatik* (2008) the music is clearly heard as being influenced by Indian and African aesthetics, yet retaining a Euro-American post-modern narrative, possibly due to the composer/programmer/performer being visible on stage, a puppet master pulling the strings of the system[2]. Non-western stylistic models could be found in the conception of the music, and the design of the system, however no direct examples of the original style were used.

Other, Previously and *Armar*

This wasn't the case in later versions of my systems, in which a corpus of stylistic examples were used to derive rules for generative purposes. *Other, Previously* (2009) used the traditional Javanese gamelan composition *Ladrang Wilugeng* [56] to derive rules for the generation and evolution of musical parts using a genetic algorithm [55][3]. The same system was used for *Armar* (2009) for four percussionists, which used traditional Cuban percussion music as a corpus. In both cases, the surface features of the model were clearly represented, while the human composer supplied the deeper formal and structural elements. The end result for the listener was curious: *Other, Previously* was orchestrated for string quartet, an extremely European ensemble; as such, the non-western influence could be heard as a form of exoticism. *Armar*, with two of its four movements orchestrated for the original Cuban instrumentation, were heard as less exotic and more as misconstrued imitation: for example, the fundamental *clave* patterns would often shift in relation to other parts, resulting in "incorrect" *Mambo* and *Mozambique* music[4].

One of the Above

A more unusual form of stylistic appropriation occurred in *One of the Above*, which consists of several movements for solo percussionist generated entirely by computational system. The intention was to create "high-modernist" music: extremely complex gestures that are difficult to perform. The unusual aspect involved audience validation: one of the four movements was human-composed, while the other three by machine, and the audience was asked to determine the difference. This was not meant as a Turing Test to prove the success of the system, but instead an effort to discover whether a computational system could accurately

[2] See http://youtu.be/R-DQ5WPd4ao for a video of this performance.
[3] See http://youtu.be/gaQfyhOiRio for a video of this performance
[4] See http://youtu.be/flCUs-uOYps for a video of this performance.

model a style, in this case, the author's own modernist style [57][5].

GESMI – Generative Electronica Statistical Modeling Instrument

Within Western contemporary art, post-modernist or otherwise, a great deal of value is still placed upon novelty; however, Electronic Dance Music (EDM) has a unique relationship between novelty and stylistic consistency. A myriad of separate styles within the genre [58] are often a combination of elements from earlier styles [59]; thus, it is important for music created within a specific style to retain very specific stylistic elements, otherwise a novel track would be considered outside the genre. Furthermore, a track's value is often based upon its ability to enforce the genre's stylistic conventions while demonstrating novelty in other aspects: for example, timbre and signal processing.

Because stylistic elements are often explicit – Wikipedia lists the "characteristics" of each style – EDM is often a project undertaken by nascent generative musician/programmers. Furthermore, EDM's repetitive nature, explicit forms, and clearly delimited style suggest a parameterized approach. As with many cases of creative modeling, initial success will tend to be encouraging to the artist: generating beats, bass lines, and synth parts that *resemble* specific dance genres is not that difficult. However, progressing to a stage where complete pieces are generated that are indiscernible from the model is another matter. In those cases, the "artistic voice" argument tends to emerge: why spend the enormous effort required to accurately emulate someone else's music, when one can easily insert algorithms that reflect one's personal aesthetic? Instead, why not generate music that is, in such cases, merely *influenced* by the corpus?

Our research within EDM has been motivated by scientific concerns – can we generatively produce complete musical pieces that are modeled on a corpus, and indistinguishable from that corpus' style? – as well as artistic: can we generate good music without being an expert in the style? [60] While GESMI has produced at least two albums worth of material that are consistent within one of two styles based on corpora of Breakbeat and House music, what I have found to be more interesting is style-mixing. For example, drum breaks occur frequently within Breakbeat music, but never within House music; by mixing the corpora of the two styles, the generated music sometimes produced unique drum breaks within a House track, a novel achievement outside of either conceptual space.

Conclusion

If one accepts that artists create unique conceptual spaces with each work – albeit spaces that are enclosed within larger spaces of their current style and the larger artistic style within which they work – the need for transformational creativity and/or Big-C creativity is not required for the acceptance of new artworks to be valued and considered creative. Even works that are never transformative can be considered masterpieces, as evidenced by compositions by Bach and Mozart. Bach was composing within the strict limitations of a late-Baroque contrapuntal style, yet managed to discover sublime combinations of pitches and rhythms that demonstrated not only his genius, but the potential for innovation within severe constraint. While current computationally creative systems based upon style modeling may not have reached such levels, they are producing novel artworks that have value, and, as such, can be considered creative.

Style modeling does not require a computer, as demonstrated by Rochberg, nor does style mixing, as evidenced by Third Stream music [61]. Computational style modeling does, however, allow for large corpora [62], much larger than could be feasibly understood by an artist; as such, the curation of such a corpora could be deemed creative and artistic in itself. While this may, on the face of it, suggest the impending irrelevance of the traditional artist, I would argue the exact opposite. The potential for neophytes to create art has always existed, and the increased power inherent in computational systems suggests this will only escalate; the separation between acceptable art and great art may narrow, but navigating the delicate balance between novelty and value will continue to require the unique characteristics of a creative artist.

[5] See http://youtu.be/gAIjQOiMG54 for a video of this performance.

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