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제1부: 한국전자음악협회 2020년 연례학술대회 선정 논문

Multimedia Analysis in Donny Karsadi's Multimedia Piece *I Hate My Stupid Brain*

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In multimedia music, sound is not the only material used which can cause problems when we are only looking at all media correlations through the sound analysis perspective. Because of this type of multimedia music, we have to find other ways to analyse it and understand how it works. In this paper, the author uses Donny Karsadi's piece entitled *I Hate My Stupid Brain* as the subject of analysis and Marko Ciciliani's method to examine how multimedia functions in music works that contain multimedia and what phenomena we can discover from multimedia relations that we rarely find in instrumental music.

Keywords: Audiovisual, Multimedia Music Analysis, New Music

Introduction

Today's composers do not just sit on chairs and write notes while composing music. Composers also develop their skill to create their artworks using video editing software, VJ tools, film and photo cameras, staging, lighting, programming languages, communication protocols, working with microprocessors, physical computing, soldering, tailoring, book layout, and many more (Ciciliani 2017: 27) which can be used to create multimedia music.

Even though the tendency of multimedia music has occurred for a long time, such as in the use of music, texts, costumes, sets, etc. in opera music or even other cultural music (like Indonesian Wayang Kulit that blends music and visuals), the composers' extra abilities are able to expand the use of multimedia which could not be realized before, for example the use of visual sonification which copies pixel values from digital images to an audio buffer (Ciciliani 2015: 91), live video, and algorithms for combining music and other aspects of multimedia music.

Currently, we can see examples of extended versions of multimedia music such as the use of live video content in Michael Beil's *Key Jack*, the use of a web-cam to capture eye movements used to process audio and visual projections in Stevie Jonathan's *Cubicle Music*, the use of light and laser projection in Marko Ciciliani's *Alias*, the use of sonification in Kittiphan Janbuala's *1(X)MB,* or the use of specific costumes, materials and staging in Jagoda Szmytka's *DIY or DIE*.

Based on these examples, in multimedia music, sound is not the only material used. Therefore, it can cause a problem when we only look at all media correlations through the sound analysis perspective. Thus, to fully understand multimedia music, we must analyse how the relationships between media are built and connected to one another.

In this paper, the author uses Karsadi's piece, *I Hate My Stupid Brain,* as the subject of analysis to examine how multimedia functions in music works that contain multimedia and what phenomena we can discover from multimedia relations that we rarely find in instrumental music.

The Piece

I Hate My Stupid Brain is a multimedia work by Indonesian composer, Donny Karsadi. Karsadi studied composition under the guidance of Otto Sidharta and Prof. Bernd Asmus at Pelita Harapan University, Jakarta, Indonesia. After graduating, he continued his composition studies with Dieter Mack at Musikhochschule Lübeck. His passion for electronic media slowly emerged during his time in Lübeck when he studied electronic music under Prof. Sascha Lino Lemke and also sensors and video techniques under Alexander Schubert. He also decided to take another degree in electroacoustic composition under Prof. Kilian Schwoon and studied audio programming under Joachim Heintz at Hochschule für Künste Bremen.

I Hate My Stupid Brain is a multimedia music for one performer, live projection and lighting, and live electronics. This work, according to Karsadi, is composed in two or three weeks and differs (read: a kind of prototype) from Karsadi's initial idea. The original idea itself will be realized in a new piece by Karsadi which will be performed in 2020 entitled *Nrimo Ing Pandum* for computer keyboards, motion sensors, projection, lights and live electronics. In this analysis, the author will focus on Karsadi's piece *I Hate My Stupid Brain* as the subject of analysis.

The stage setting of *I Hate My Stupid Brain* in the Youtube video sourced from the author for this analysis shows several differences from the original set where the guitarist's ideal position should be in the 'projection space'. The guitarist should be halfway between the visual projection of the guitar sound on the left and right, and the guitarist must be under the visual projection of the 'A.I. voice'. In this piece, the term 'A.I. voice' has nothing to do with the use of artificial intelligence, but simply means a computer-generated voice. Next, the author will use the term 'computer-generated voice' to describe the 'A.I. voice' that Karsadi mentions in Figure 1 and in the interview section. The author will use Karsadi's piece *I Hate My Stupid Brain* uploaded on Youtube for the analysis.

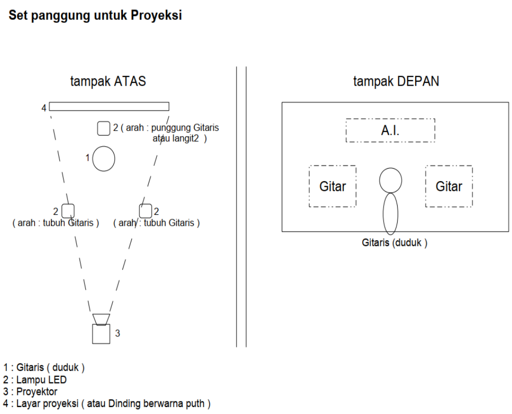

Figure 1. Original setting. Sketched by Donny Karsadi.

Karsadi explained by email that this piece is divided into three sections. The first section includes the light projection, the guitar sound and live electronic followed by texts (the text transcription will be explained in the next chapter) projected onto the screen as the opening of the first section.

In the second section, the text is removed from the screen and only guitar sounds, live electronic and light projection are left with more 'agitated' characteristics than the former in terms of rhythmic patterns.

In the third section, the characteristic becomes contrast and very fluid, the visual returns to the screen but this time with different shapes (similar to a cubism pattern). The text also disappears from the screen.

In an interview arranged by email, Karsadi also fully explains the piece with an analogy:

> The idea may be associated with a silly romance. I prefer to explain with this analogy: The story of someone who feels lonely, then tries to 'pedekate' (*flirt*) on A.I. like Siri/Alexa (Section 1) but fails, even ends up fighting. Afterwards, he attempts to distract himself by finding another activity by playing a few interrupted phrases (Section 2) until finally feeling bored and falling asleep (Section 3). The first and the third section have a similar (abstract) feel, while the second section is more playful, the beats and notes are a little clearer and can be followed. Thus, the three sections have abstract - less or even a little abstract - abstract. (Septian Dwi Cahyo, personal email, 12 May, 2020).

There are several interesting features that the author finds in this piece. In section 1, the guitar and the computer-generated voice 'are communicating' through projected texts on the screen. Karsadi explains that this part has 'an abstract structure', which means playing irregular rhythmic patterns and phrases. In section 2, the structure is 'less abstract' as it has more stable rhythmic patterns, while the structure in section 3 is 'abstract' because the atmosphere becomes more fluid without clear rhythmic patterns. At last, the author is also intrigued by the congruence and divergence between media, which will be explained later in another chapter of this paper.

Analysis Method

There are several methods to understand how auditory and visual elements work in multimedia. These methods are proposed by Nicholas Cook, Shin-Ichiro Iwamiya and Marko Ciciliani.

In Cook's book, *Analysing Musical Media,* he offers three basic models of multimedia that he calls: *conformance, complementation,* and *contest* (Cook 1998: 98). C*onformance* happens when the sound and image amplify each other (Ciciliani 2017: 476). Cook provides an example of how color-sound in Scriabin's *Prometheus* cannot be said to be conformant because the slower luce part in Scriabin's *Prometheus* does not relate in any such direct manner to the music part (Cook 1998: 100). *Contest* happens when each media attempts to impose its own characteristics upon the other (Cook 1998: 103), and *complementation* happens when each media projects their attributes to the other medium (Ciciliani 2017: 476).

In Iwamiya, the combined auditory and visual phenomena in multimedia are only divided into two categories, namely *formal congruency* and *semantic congruency*. In Iwamiya's paper, formal congruence is defined as the matching of auditory and visual temporal structure (Iwamiya 2013: 141). It provides a unified form of perception for auditory and visual information. Semantic congruency is defined as the similarity between auditory and visual affective impression (Iwamiya 2013: 141). It helps to communicate the meaning of audiovisual content to perceiver.

However, for this analysis, the author prefers to use Ciciliani's method. This method has more categories that fit to analyse congruence and divergence among media and to investigate the relationship between the media used in Karsadi's piece. This method is used to analyse audiovisual and multimedia in order to 'dissect' relationships between media, such as event synchronization, semantic correspondence, etc. This method also offers valence/potency/activity graphs that enables us to draw schematic of change of congruence and divergence that occurs in a multimedia piece for an analysis purpose.

There are three categories with several parameters in each category that can be used as a tool to investigate congruence and divergence between media in Ciciliani's method, such as:

Category of Mapping
Category of Indices
Category of Atmosphere

1. Mapping

There are three parameters in this category such as divergence/congruence in terms of synchrony, divergence/congruence in terms of space, and divergence/congruence in terms of mass.

1.1 Divergence/congruence in terms of synchrony
Within this parameter, congruences or divergences are in terms of synchrony where the visual event is associated with an aural one, and it needs to occur simultaneously. This parameter indicates whether auditory and visual phenomena are predominantly synchronized (Ciciliani 2017: 478).

1.2 Divergence/congruence in terms of space
The second parameter of this category refers to space and indicates if the spatial arrangement of sounds and elements in the image correspond spatially (Ciciliani 2017: 478).

1.3 Divergence/congruence in terms of mass
The third parameter indicates if sonic and the visual phenomena correspond in terms of size or apparent weight. For example, objects that are larger in the visual part are associated with lower or louder sound.

2. Indices

This category only has two parameters, namely divergence or congruence in terms of semantics and divergence or congruence in terms of idiom.

2.1 Divergence/congruence in terms of semantics
This parameter indicates whether an audiovisual work exhibits a profiled relationship between media of a semantic nature. Here semantic refers to any meaning that is superior to what is evident as a visual or aural phenomenon. These can be a concrete meaning–as in a narrative context, a symbolic reference, or emergence meaning (Ciciliani 2017: 478).

2.2 Divergence/congruence in terms of idiom
This parameter expresses whether there is congruence or divergence between the idioms or styles that each medium uses (Ciciliani 2017: 479).

3. Atmosphere

The three parameters in this category describe the characteristics of the relations between media, which are rather evasive and cannot easily be attributed to a single concrete principle.

3.1 Divergence/congruence in terms of kinetics
This parameter has similarity to the parameter of synchrony. However, if the parameter of synchrony is closer to rhythm synchronization, then this parameter refers to a more general sense of motion, tempo and speed.

3.2 Divergence/congruence in terms of salience/fidelity
This parameter describes the balance between different media and whether one strongly dominates over the other (salience), or whether one is designed in much greater detail than the other (fidelity) (Ciciliani 2017: 479).

3.3 Divergence/congruence in terms of tinting
This parameter addresses perhaps the least tangible aspects of a work, namely the general moods that the media express–here expressed as tinting (Ciciliani 2017: 479).

Discussion

This analysis is divided into three parts following Karsadi's piece structure. In the first part, the author focuses on analysing the relationship between media, particularly between the projected text on the screen, the sound from the guitar and the computer-generated voice.

In the second part, since the text represented by the guitar and the computer-generated voice is no longer present, the author focuses on analysing the congruence of the sound and light projection part.

In the third part, the author analyses the congruence of new visual material on the screen, light projection and sound. The author utilizes Ciciliani's method as a starting point for analysing congruences of media in Karsadi's piece.

1. First Section Analysis

The first section lasts between 00'00'' to 03'06''. At the beginning of this section, from 00'00'' to 00'28'', there is a congruence in terms of synchrony that the accentuation of the sound is synchronized with the accentuation of the light projection.

After this opening, Karsadi‘s piece continues to be a part without accentuated light projection. Then, from the minutes 00‘28’’ to 02‘24’’, the computer-generated voice, the electronic sound and the text on the screen start playing simultaneously.

At first experience, we may find these three media moving arbitrarily and without any linking materials. However, from Karsadi‘s statement in the interview arranged by email, the author finds that there is a congruence in terms of idiom:

> The guitar player ‘is flirting’ with the A.I. The projection of the guitar sound is abstract because the phrases that the guitar plays are also abstract. Siri (A.I. voice) speaks in English and she has a ‘translation/subtitle’ whose content is completely different from what she said. For example, she said “yes” in the spoken voice part, but actually what she means is “no” in the text part (Septian Dwi Cahyo, personal email, 12 May, 2020).

This happens when the guitar sound described by Karsadi as an abstract material has congruence with the abstract letters style of the text projected on the screen.

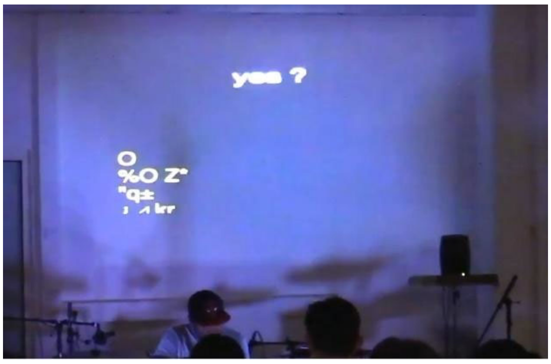

Figure 2. Abstract letters.

Regarding the relationship between the computer-generated voice and the projected text that acts as the translation/subtitle of the computer-generated voice, the text shows the opposite of what the computer-generated voice speaks. We can see in the transcription below, the left side is the spoken part of the computer-generated voice while the right side within the brackets is the translation/subtitle of the computer-generated voice in the form of texts projected on the screen:

Hello there (yes?)

How can I help you (what do you want?)

No worries (argh…)

It is my pleasure to help (what a pain the a@^!\>>)

oh (bah)

I’m single, how about you (it’s none of your f#%아킹 business)

That’s unfortunate (haha..)

I wish you found someone in the near future (loser..)

What (huh?)

I’m here to assist you with your needs (what a perv..)

oh (ew..)

not that kind of need (get the fudge out of here!)

sure (well)

please wait a moment (sit your a &/!”§ss?’ down)

I’m trying to find the best way (I’ll go and take a dump)

Search completed and find no best way other than K.I.L.L. yourself (oh, you’re still here.. hmmm.. I thought you left already.. I cooked yome meatloaf, do you want some?)

oh (awe..)

you ungrateful son of a bi$!tch (that’s so sweet of you)

no (yes)

you (you are..)

you son of a bi$!tch (you are so charming)

Okay then (I see..)

I’ll tell them to pull you down (then I’m going to hold you in my arms)

pin you hard (and never let you go)

and shit directly into your mouth (and shower you with thousands of kisses)

what do you say about that (what do you say to that?)

Okay (oh okay then..)

I can just shoot your mouth with a B.B Gun (whatever you say, I’ll follow you ‘till the end of the world)

you don’t like that (I know you’ll love that idea)

then (so)

Fu!$%ck off (come closer)

Goodbye handsome (closer)

Wish you have a nice day (closer)

From the computer-generated voice and its translation/ subtitle, at first glance we cannot see clearly whether there is congruence in that section. However, if we look at Karsadi’s statement:

> For example, she said “yes” in the spoken voice part, but actually what she means is “no” in the text part.

we can see a strong sign that the computer-generated voice and its translation/subtitle has a hidden connection that provides semantic information. The computer-generated voice tries to be ‘polite’ to the guitar part that ‘flirts’ her, but her actual response is contradictory and is projected as text on the screen.

This hidden relationship reminds the author of the *Gehalt* aesthetic and the idea of relational music by Harry Lehmann. The German concept of *Gehalt* cannot be properly translated into English. The *Gehalt* of an artwork is not the traditional pre-existent ‘content’, but rather must be experienced by the recipient through the process of interpretation (Lehmann 2006: 31).

This G*ehalt* can only appear in relational music. Compared to relational music, the extra music in programmatic music (movements, images and texts) can be completely musicalized (i.e. when Rimsky Korsakov converts the sound of bees to musical rhythms in *The Flight of Bumblebee*). On the other hand, relational music retains its reference to the world, its reference to something that is no longer music (Lehmann n.d.).

In relational music, the musical relatum (texts, images, videos, etc.) exists as it is and does not transform into musical material. The *Gehalt* in relational music occurs when every medium (music, text, visual) acquires semantic meaning. This *Gehalt* in Karsadi's piece appears when the text pronounced by the computer-generated voice contradicts the translation/subtitle which is projected as text on the screen. This delivers a hidden meaning to the guitar sound that 'flirts' with the computer-generated voice.

That part is a kind of symbolic reference of 'rejection' which is quite close to congruence in terms of semantics, where semantics refers to any meaning and this can be a concrete meaning–as in a narrative context, a symbolic reference, or an emerging meaning.

Starting at 02'23'' and lasting up to 03'08'', the text disappears, then the light and sound projection begins to show a congruence in terms of synchrony again where the 'accentuation' of the electronic sound is synchronized with the 'accentuation' of the light projection. In this part, the computer-generated voice only appears for a moment until the computer-generated voice acts as a reverb effect that brings the piece to the second section.

In the transition to the second section, there is a congruence in terms of space that develops between the minutes 03'03'' to 03'07''. This occurs when the live pulse electronic sound in the center of the loudspeaker matches the projection position of the light in the center. Apart from showing congruence in terms of space, this part also demonstrates congruence in terms of synchrony between the rhythm of sound and light projection.

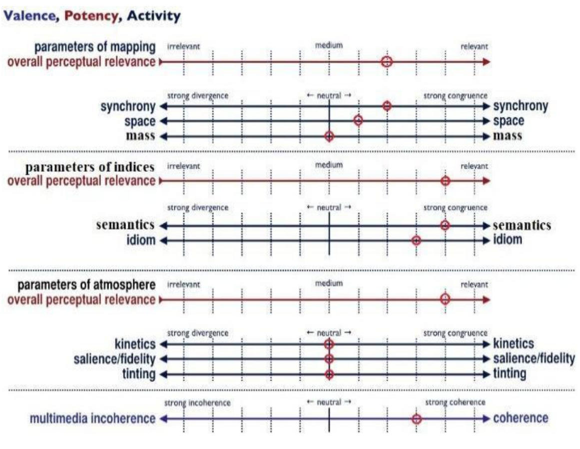

Figure 3. Valence, potency, activity of the first section.

To summarize the analysis of each section, the author applies Ciciliani's valence, potency and activity graph. This graph enables us to show parameter values from each divergence or congruence in the analysed piece. This graph contains each category with its parameters. As shown in the graph, there are lines that indicate the value of each category and its parameters. The right side shows relevant and congruence values, while the left side indicates irrelevant and divergence value. The image below shows the graph of valence, potency, and activity of the first section.

2. Second Section Analysis

The second section starts at 03'09'' and lasts at 05'44''. The character of this section is more rhythmical than the first section. The author also finds congruence in terms of synchrony and tinting dominating this section where light and sound projection are matched in terms of rhythmic synchronicity.

From the minutes 04'50'' to 05'00'', the characteristic has slightly changed for a while. The author notices there is a congruence in terms of kinetics occurring in this part when the projections of sound and light begin to slow down the tempo for ten seconds, before returning to the previous rhythmical character. Congruence in terms of tinting also seems to dominate the second section of this piece.

Between 05'30'' and 05'47'', a congruence in terms of kinetics begins to reappear as the tempo of sound and light projection starts to increase to emphasize the transition to the third section.

Overall, the second section contains three congruences, including congruence in terms of tinting, congruence in terms of synchrony, and congruence in terms of kinetics. In the second section, the sound that represents the light projection at 03'03'' to 03'37'' reappears at 04'04'' to 04'27'', but the sound moves from right to left and vice versa with the light projection remaining in the center position. This shows divergence in terms of space.

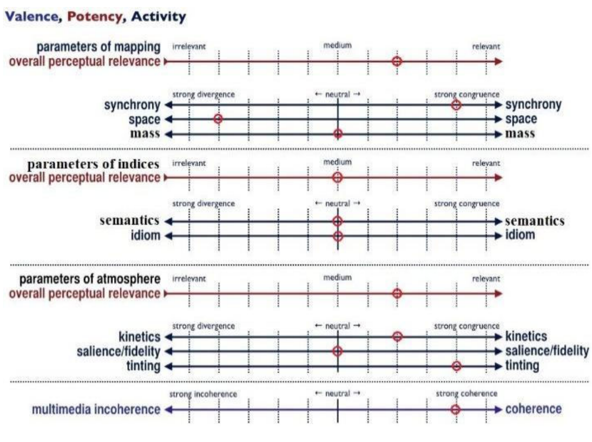

Figure 4. Valence, potency, activity of the second section.

3. Third Section Analysis

The third section starts at 05'43'' and lasts at 08'20''. The characteristic of this section is less rhythmical and more fluid. If Karsadi's metaphor is applied, then this section is more abstract than the second section. The mood of light projection and sound is very close to congruence in terms of tinting. In addition, the light projection and sound which displays the impression of slow motion to 'finish' the hectic rhythm of the second section is counted as congruence in terms of kinetics.

The interesting part in this section is the new visual material that appears on the screen. Several cubism patterns flickering at a fast tempo, which reminds the author of the rhythmic characteristic of the second section from 05'41'' to 07'45''. It provides 'semantic' information and is juxtaposed in the author's perception. This phenomenon creates multiple layers of congruences.

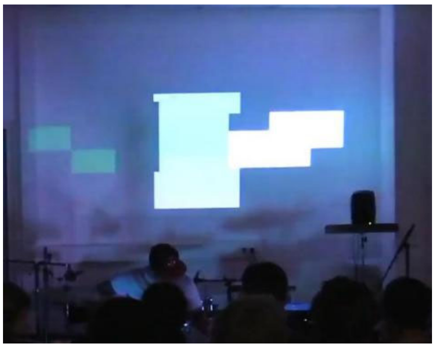

Figure 5. Cubism pattern in the third section.

At the end of this section, (approximately at 07'57''), the author rediscovers a juxtaposition of congruences between congruence in terms of synchrony and congruence in terms of kinetics. It occurs when the light projection, the cubistic visual and the sound match in terms of rhythmic synchronicity. The increased amplitude of the sound plus the adjacent sound layer also offers a sense of acceleration toward the end of this piece.

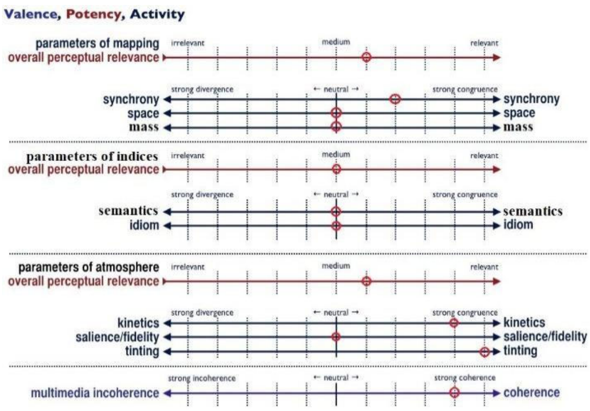

Figure 6. Valence, potency, activity of the third section.

A Complete Analysis Graph

To summarize the analysis from the first to the third section, the author uses various forms of Ciciliani's valence, potency and activity graph. This graph is a little different when compared to the graph in each section. There is a dotted line in the middle, which divides the congruent half from divergent.

This graph also allows us to provide the parameter values of any divergences or congruences, and the relevant or irrelevant values that occur in the analysed piece. This graph also contains each category with its parameters.

In each parameter, the dotted line in the middle divides the congruence and divergence part. If we place the dots as an indication of the parameter value above the midpoint dotted line, it represents more congruence than divergence. The higher the congruence value given, the higher the congruence value that occurs in that parameter. If we place the dots as an indication of the parameter value below the midline, it represents more divergence than congruence. The lower the dots are below the midpoint line, the higher the divergence value that occurs in that parameter. On the other hand, if we place the dots on the midpoint line, it means that the value is neutral between congruence and divergence.

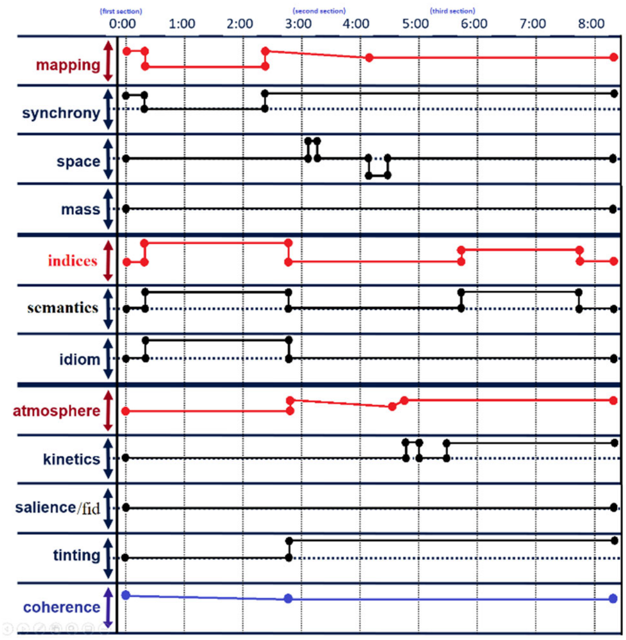

Figure 7. Valence, potency, activity of all sections.

Conclusion

Based on Karsadi's piece and Ciciliani's method, the author finds that multimedia music works by combining many aspects of the media. This combination of media is not as an arbitrary activity or as a background from one media to another, but each media has a balanced role. This combination of media also has its own correlation and congruences (style congruence, semantic congruence, and so on).

Another interesting phenomenon that we rarely see in instrumental composition is how multimedia music can provide more space. That is, with the use of multimedia, composers are able to place semantic information through a hidden relationship or *Gehalt* produced by a combination of media that acquire several layers of perception simultaneously such as visual perception, sound perception and so on.

A hidden relationship creates semantic information generated by juxtaposing activities between each media, where one media provides information to another, as in the first section of Karsadi's piece. This hidden relationship in Karsadis's piece shows the semantic meaning of the opposite phenomenon, when the spoken text produced by the computer-generated voice and the text projected on the screen provides a 'symbolic' answer to the 'flirting' activity performed by the guitar part.

Acknowledgments.
I would like to thank Donny Karsadi for his assistance with several questions for the purpose of this analysis. I also thank Alyssa Aska and Putu Tasya Sanjivani Oka for their help in examining this paper.

References

Ciciliani, M (2015). SCANLINE SYNTHESIS AS A SONIFICATION METHOD FOR DIGITAL IMAGES: TECHNIQUES AND AESTHETICS – A CRITICAL REFLECTION. In *proceedings of understanding visual music 2015 symposium*: 91-101. Brazil: Universidade de Brasília, Pós-Graduação em Arte.

Ciciliani, M. (2017). A Method for Subjective Analysis of Audiovisual Works. In *Proceedings of the International Computer Music Conference 2017*: 476-481. Shanghai: ICMC/EMW.

Ciciliani, M. (2017). Music in the Expanded Field – On Recent Approaches to Interdisciplinary Composition. In Rebhahn, M., Schäfer, T. [Ed.]. *Darmstädter Beiträge zur Neuen Musik*: 23-35. Mainz: Schott.

Cook, N. (1998). Analysing Musical Multimedia. Oxford & New York: Oxford University Press.

Iwamiya, Shin-Ichiro. (2013). Perceived congruence between auditory and visual elements in multimedia. In Tan, Siu-Lan et al. [Ed.]. *The Psychology of Music in Multimedia*: 141-164. Oxford: Oxford University Press.

Lehmann, H. (2006). Avant-garde Today. A Theoretical Model of Aesthetic in Modernity. In *Critical Composition Today*: 9-42. Hofheim: Wolke.

Lehmann, H. (n.d). relationale Musik. Retrieved September 9, 2020, from http://www.harrylehmann.net/begriffe-2/#relationale-musik

Video Examples

Karsadi, Donny: *I Hate My Stupid Brain*, 2018, Retrieved from https://www.youtube.com/watch?v=GEYTO3uSm4k [Accessed August 20, 2020].

Jonathan, Stevie: Cubicle Music, 2018, Retrieved from https://www.youtube.com/watch?v=djFyGMDt_BE [Accessed December 31, 2020].

Janbuala, Kittiphan: 1(X)MB, 2019, Retrieved from https://www.youtube.com/watch?v=2Zg5wEGmJm0 [Accessed December 31, 2020].

Ciciliani, Marko: Alias, 2007, Retrieved from https://www.youtube.com/watch?v=fQaVo5byn5w [Accessed December 31, 2020].

Beil, Michael: Key Jack, 2016, Retrieved from https://www.youtube.com/watch?v=LKprAEkG1j0 [Accessed December 31, 2020].

Szmytka, Jagoda: DIY or DIE, 2017, Retrieved from https://www.youtube.com/watch?v=dhJLj7Y47FQ&list=PLpoSgJkK5-PnJ8zRCrRoVcCJPeuaDJqh9 [Accessed December 31, 2020].

[Abstract in Korean | 국문 요약]

도니 카르사디의 멀티미디어작 "내 어리석은 두뇌가 싫다"의 다중매체적 분석

셉티안 드위 카효

멀티미디어 음악에서, 소리를 분석하는 관점을 통해 모든 매체의 상관관계를 바라볼 때 문제가 되는 재료는 소리만이 아니다. 이러한 유형의 멀티미디어 음악이 있기 때문에, 이들을 분석하고 어떻게 작동하는지 이해하기 위해 다른 방법을 찾아야 한다. 이 글에서, 저자는 "내 어리석은 두뇌가 싫다 I Hate My Stupid Brain"라는 제목의 도리 카르사디 Donny Karsadi의 작품을 분석의 주제로 삼고, 멀티미디어를 포함한 음악작품에서 어떻게 멀티미디어가 기능하는지와 기악음악에서는 찾기 어려운 다중매체적 관계에서 어떤 현상이 발견되는지 분석할 수 있는 마르코 시실리아니Marko Ciciliani의 방법론을 사용한다.

주제어: 시청각(오디오비주얼), 멀티미디어 음악 분석, 뉴 뮤직

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[Keynote Speech]

Some Histories and Futures of Making Music with Computers

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Having spent decades working in the field of Computer Music, I review some major trends of artistic and scientific development in the field with an eye to the future. While the implications of exponential computational growth are hard to predict, it seems that musical imperatives remain stable; thus, they will continue to guide us in the future. I predict a number of "futures" for Computer Music based on the persistent themes of sound creation, music representation, and music performance.

Keywords: History of computer music, Futures of making music with computers, Moonshot project.

[기조연설]

컴퓨터로 음악만들기의 어떤 역사와 미래

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수십년간 컴퓨터음악 분야에 종사하면서 내가 겪었던 몇몇 주요한 예술적, 과학적 발전 경향을 이 분야의 미래에 대한 관점과 함께 되짚어본다. 기하급수적인 컴퓨터 성장의 영향정도를 가늠하기란 어렵겠지만, 음악에 대한 요구조건에는 변함이 없어 보인다; 그러므로, 우리는 이 요구조건들을 통해 미래의 길을 따라가 볼 수 있을 것이다. 나는 사운드 창작, 음악적 표현, 그리고 연주 실행이라는 지속적인 주제를 바탕으로 한 컴퓨터음악의 몇몇 "미래들"을 예측해본다

주제어: 컴퓨터음악의 역사, 컴퓨터로 음악만들기의 미래, 문쇼트 프로젝트.

Like computing itself, Computer Music has experienced rapid growth over sixty years or so. We have seen an evolution starting from primitive but pioneering attempts to create the first digital musical sounds and to create and control music algorithmically. Our current state of the art now includes very sophisticated real-time signal processing, flexible software languages and architectures, and commercialization that reaches billions of creators and consumers. I am honored to address the KEAMS Annual Conference 2020, and I would like to take this opportunity to look both backward and forward with an aim to better understand the field and perhaps to gain some insights into future artistic opportunities and scientific directions.

Most of my work in the field has been scientific, but I feel that my work has always been guided by my experience as a performing musician and composer. My early interests in math, music and engineering led me to analog music synthesizers as well as computers in my teens. (I should add that computers around 1970 were rarely encountered outside of businesses and universities.) Through college, I learned enough electrical engineering to design and build a hybrid digital and analog synthesizer as well as a microcomputer of my own design and wired by hand, but I was pretty ignorant of emerging research. At least I was well prepared to suddenly discover a small but growing literature from authors and editors such as Max Mathews, Jim Beauchamp, John Chowning and John Strawn. I spent my years in graduate schools in more mainstream Computer Science, but on the side, I devoured everything I could find to read on Computer Music. I emerged from graduate school with a junior faculty position and a very supportive, open-minded senior faculty including Nico Habermann, Raj Reddy, Alan Newell, Herb Simon, and Dana Scott. Ever since then, I have been very fortunate to follow my passion for Computer Music making and research. I have closely followed and participated in over four decades of Computer Music development.

컴퓨터의 사용 자체가 그러했듯, 컴퓨터음악은 지난 60여 년간 급속한 성장을 경험했다. 우리는 원시적이었지만 선구적이었던 첫 디지털 음악 사운드를 만드는 시도부터, 알고리즘으로 음악을 창작하고 제어하는 데까지 진화를 목격했다. 지금 예술의 현 수준은 매우 정교한 실시간 신호처리와 유연한 소프트웨어 언어와 구조체계architectures, 그리고 수십억의 창작자와 소비자를 포괄하는 상업화에까지 이른다. 나는 2020년 한국전자음악협회 연례학술대회에서 연설하는 것을 영광으로 여기며, 과거와 미래를 살펴봄으로써 이 분야를 보다 잘 이해하고, 미래의 예술적 가능성과 과학적 방향성에 대한 통찰을 얻는 기회를 갖고자 한다.

나는 이 분야에서 대부분 과학적인 작업들을 해왔지만, 연주하는 음악가이자 작곡가로서의 경험이 언제나 그 작업들을 이끌었다고 느낀다. 내가 10대 때 수학과 음악, 공학에 대한 초기의 관심이 아날로그 뮤직 신서사이저와 컴퓨터로 이어졌다. (1970년경 컴퓨터는 기업이나 대학 외에서는 접하기 어려웠다는 점을 덧붙인다.) 대학시절, 나는 디지털과 아날로그 혼합의hybrid 신서사이저 뿐 아니라 내가 직접 디자인하고 배선한 개인 컴퓨터를 설계하여 만들만큼 충분한 전자공학을 익혔으나, 새롭게 떠오르는 연구 분야에는 꽤 무지했다. 최소한 나는 맥스 매튜스Max Mathews, 짐 보샹Jim Beauchamp, 존 차우닝John Chowning, 존 스트론John Strawn과 같은 저자 겸 편집자의 작지만 점차 성장하고 있는 문헌들을 불현듯 발견할 만큼은 준비되어 있었다. 대학원에서 수년간은 보다 주류의 컴퓨터 공학을 공부했지만, 한편으로는 내가 찾을 수 있는 한 모든 컴퓨터음악에 대한 읽을 거리를 찾아 탐독했다. 내가 대학원에서 초급 교수직을 맡았을 때, 니코 하버만Nico Habermann, 라 레디Raj Reddy, 앨런 뉴얼Alan Newell, 허브 사이먼Herb Simon, 다나 스콧Dana Scott을 포함한 매우 협조적이며 열린 사고를 가진 상급 교수진을 만나게 되었다. 그 이후로 죽, 컴퓨터음악을 제작하고 연구하는데 나의 열정을 쫓아 가는 행운을 얻게 되었다. 나는 40년 이상 컴퓨터음악 발전 과정에 깊숙이 관여하며 함께해왔다.

In this presentation, I wish to review some of my own work, which like all research is tangled in a network of other ideas and influences. From this, I hope to draw some understanding of the big ideas that drive the field forward. The occasion of a keynote address is one of those rare opportunities where one can be controversial and speculative. I will take this chance to make some predictions of where we might be going in the future. I have titled this talk in the plural: both “histories” and “futures” to hedge my bets. There are multiple ways to organize the past and multiple possibilities for the future. And speaking of the title, the phrase “with Computers” is purposefully ambiguous, regarding computers as both tools and collaborators. I will surely omit some important history and fail to anticipate much of what is yet to come, but I hope these ideas might inspire some or at least offer interesting insights.

이 발표에서, 모든 연구가 그러하듯 여러 다른 아이디어와 영향력이 네트워크로 얽혀 있는 몇몇 나의 작품들을 살펴보고자 한다. 이를 통해, 컴퓨터음악이 진일보할 원대한 생각에 관한 이해를 이끌어낼 수 있기를 바란다. 기조연설의 경우는 논쟁적이거나 추론적으로 사고해볼 수 있는 드문 기회일 것이다. 나는 이 기회를 빌려 우리가 미래 어디쯤 가 있게 될 것인지 몇 가지 예측을 할 것이다. 이러한 나의 불확실한 예측의 위험성을 보완하고자 나는 이 연설 제목에서 "역사들"과 "미래들" 양쪽에 복수형을 사용했다. 과거를 정리하는 데 여러 방식과, 미래에 대한 다양한 가능성이 존재하기 때문이다. 그리고 제목에 대해 말하자면, "컴퓨터로"라는 문구는, 컴퓨터를 도구로서와 창작에 협력 주체로서 간주하므로, 다의적 의미를 의도한다. 나는 분명 몇몇 중요한 역사를 빠뜨리고 향후 오게 될 것들 중 많은 점들을 놓치게 되겠지만, 이러한 나의 논의가 누군가에게 영감을 주거나 적어도 흥미로운 식견이 될 수 있기를 희망한다.

Why Computer Music?

Anything new, any break with tradition, is going to raise questions. For some, computers and music seem a natural combination – why not? For others, as if the pursuit of Computer Music detracts from something else, what is the point? I have been collecting answers for many years, although I think there are really just a few. One idea that I was introduced to by F. Richard Moore is the *precision* that digital computation brings to music. Instead of music where every performance is unique, computers give us the possibility of precise reproduction, and thus incremental refinement of sounds with unprecedented levels of control.

Another important idea is that composers, rather than create directly, can create through computational models of composition. This has two implications. The first is that computational processes can be free of bias, so just as a tone row might help to liberate a composer from tonal habits, a computer model might create new musical structures and logic that the composer could not create directly. The second implication is that composers can inject new musical logics or languages into real-time interactive performances. This enables a new kind of improvised music where performers are empowered to bring their expressive ideas to the performance, but computers can enforce the compositional plans and intentions of the composer. It is as if the computer program becomes a *new kind of music notation*, constraining the performer in some respects, but leaving expressive opportunity in others. In my view, this is a powerful extension of aleatoric writing, which prior to computing found only limited ways to split musical decisions between the performer and composer.

왜 컴퓨터 음악인가?

새로운 것, 전통과 단절된 어떠한 것은 의문을 가지게 한다. 누군가에게 컴퓨터와 음악은 자연스러운 결합으로 보인다 – 왜 안되겠는가? 다른 누군가에게는 마치 컴퓨터 음악을 만드는 것이 다른 어떤 것을 훼손하는 것처럼, 요점이 무엇인가 묻는다. 내가 생각하기에 실제로는 몇 개 되지 않겠지만, 나는 여러 해 동안 해답을 찾아 모아왔다. 첫 의견은 리차드 무어Richard Moore가 알려준 것으로, 디지털 계산 처리가 음악에 부여하는 '정확성precision'이다. 모든 음악이 각기 다르게 연주되는 것과 달리, 컴퓨터는 정확한 재생산과, 그에 따라 전례없이 높은 수준의 제어력으로 소리의 추가적인 개선이 가능하다.

또다른 중요한 의견은, 작곡가가 직접 창작하지 않고 컴퓨터 전산처리를 통한 작곡 모델을 사용하여 창작할 수 있다는 것이다. 이에는 두 가지 방식이 있다. 첫째로 전산 처리는 편향에서 자유로울 수 있기 때문에, 한 음렬이 작곡가의 조성적 습관에서 벗어나도록 돕는 것처럼 컴퓨터 모델이 작곡가가 스스로 할 수 없는 새로운 음악적 구조와 논리를 만들어 주는 것이다. 두 번째 방식은 작곡가가 실시간 인터랙티브 공연에서 새로운 음악적 논리와 언어를 실시간으로 적용하는 것이다. 이것은 공연 시 연주자의 생각대로 연주할 수 있는 권한이 주어지는 즉흥 음악의 새로운 종류를 가능케하는데, 컴퓨터가 작곡가의 작곡 계획과 의도대로 즉흥 연주를 실행할 수 있게 된다. 이는 마치 컴퓨터 프로그램이 하나의 새로운 악보가 되어서, 어떤 면에서는 연주자를 제한하기도 하지만, 다른 면으로는 표현할 여지를 남겨두는 것 과도 같다. 나의 관점으로 보면, 이것은 컴퓨터를 사용하기 이전에는 그저 연주자와 작곡자가 음악적 결정을 제한된 방식으로만 나눌 수 있었던 우연성 작곡기법aleatoric writing이 강력하게 확장된 것이다.

These rather technical rationale for Computer Music, important as they may be to justify our work, are really just excuses for us to do what we love to do. Humans have an innate fascination with technology and automation. As soon as you tell someone that a robot is involved, the story is immediately interesting. Experiments by my advisee Gus Xia, *et al*. (2016) give evidence to what I call the "robot effect:" Suppose a human performs along with an audio recording, as in mixed music performances. How can we make the performance more engaging for the audience? One approach is using interactive, responsive, automated computer accompaniment. This in fact does not help much. Another approach is humanoid robot performers playing a fixed score, as in animatronics, but this does not help much either. However, if we *combine* computer accompaniment with humanoid robots to create *interactive robot performers*, then the audience finds the performance more engaging and more musical! This is evidence that we *are* innately attracted to the automation of human tasks, and what could be more human than making music?

All of the ideas above combine with a basic urge to explore and learn. Do we really need an excuse or rationale? Let us pursue our passion and see where that leads. After so many contributions to the arts, science, and culture, we no longer have to worry whether we are on a good path. Let us now try to characterize the path we are on and where it might lead.

이러한 컴퓨터 음악의 기술적 근거가 우리의 작업을 정당화하는데 중요할 수 있겠지만, 사실 이는 우리가 하고싶은 일을 하기 위한 변명일 뿐이다. 인간은 테크놀로지와 자동화에 본능적으로 매력을 느낀다. 당신이 누군가에게 로봇과 연관이 있다고 말하는 즉시, 그 이야기는 관심을 끌 것이다. 나의 조언자 거스 시아Gus Xia 등의 실험(2016)이 내가 "로봇 효과"라 부르는 것에 대한 증거이다: 한 사람이 어쿠스틱-전자음악 혼합 공연에서 녹음된 오디오와 함께 연주한다고 가정해보자. 어떻게 청중들이 공연에 더 끌리도록 할 수 있을까? 한 가지 방법으로 컴퓨터의 상호작용, 반응유도, 자동반주를 시도해 본다. 그다지 큰 도움이 되지 않는다. 또 다른 방법으로 애니마트로닉스 (영화촬영용 로봇)처럼 인간형 로봇 연주자가 악보를 읽고 연주하도록 해보지만, 이 역시 별 도움이 못된다. 그런데, 컴퓨터 반주와 '인터랙티브하게 반응하며 연주'하는 인간형 로봇을 '결합'하면 청중은 보다 매력적이고 음악적으로 공연을 즐기게 된다!! 이는 우리가 사람이 하는 일의 자동화에 선천적으로 끌린다는 증거이자, 무엇이 음악을 만드는 것보다 더 인간적일 수 있겠는가?

위의 모든 논의들은 탐구하고 배우려는 기본적인 욕구를 겸비하고 있다. 여기서 변명이나 근거가 진정으로 우리에게 필요한가? 우리의 열정을 따라 나아가고 어디로 가게 되는지 보자. 예술과 과학, 문화에 수많은 성과가 축적된 후에, 더 이상 우리가 옳은 길로 가고 있는지 아닌지 걱정할 필요는 없다. 지금은 우리가 가고 있는 길, 어딘가로 이끌 길을 특징지워보자.

The Computer Music Dream

Taken as a field, Computer Music is following a path that reflects our general understanding of music. First, *sound* is a critical attribute of music. Thus, from the very beginning, Computer Music was about making sound, combining digital signal processing with digital computation to create musical tones. One could argue the first tones were hardly musical, but through many years of research, our capacity to create musical sounds surely surpassed even the wildest dreams of early researchers.

The second critical attribute of music is organization in time, exemplified by music notation. A great deal of early research concerned musical scores, note lists, music representation and music control. Just as sound synthesis has imitated the centuries-long development of acoustic instruments, music representation and control research has imitated centuries of development of music notation, from the development of neumes in the 9th century and common practice notation, to graphic notations developed in the last 70 years or so.

컴퓨터 음악에의 꿈

한 분야로서 컴퓨터 음악은 음악에 대한 일반적인 이해를 바탕으로 그 경로를 따라 나아가고 있다. 첫째, "사운드"는 음악에서 결정적인 속성이다. 그러하기에, 아주 초반부터 컴퓨터 음악이란 디지털 신호처리를 디지털 전산과정과 결합하여 음악적인 음으로 바꾸어 내는, 소리를 만드는 것에 관한 것이었다. 누군가는 첫 소리가 음악적이라 보기 어렵다고 반박할 수 있겠으나, 수 년의 연구를 거친 음악적 사운드를 창조하는 우리의 역량은 초반기 연구자들의 가장 원시적이었던 꿈조차 확실히 뛰어넘는 정도이다.

음악의 두번째 중요한 속성은 시간의 재구성으로, 이는 악보로 제시된다. 수많은 초기 연구들이 악보와 음 리스트, 음악적 표현법과 제어법을 다루었다. 소리 합성법이 악기가 수세기 동안 발전해 온 것을 모방하였듯, 음악적 표현 및 제어에 대한 연구는 9세기 네우마와 통례적인 기보법의 발명부터 지난 70여년간 개발되어온 그래픽 기보법까지 수세기간 발전한 기보법을 모방하였다.

Western music assigns importance to both planning by composers and execution by performers, and thus music often has *two* characteristic representations: the score that represents instructions to performers, and live sound or recordings which convey the performance “product” to listener/consumers. (The same property holds for plays, film, and to some extent architecture and dance). Thus, a third thread of Computer Music research is an exploration and automation of performance, including interaction, expressive interpretation of scores, jazz improvisation, and performance style.

Although highly reductionist, I believe these three threads: *sound generation*, *music representation*, and *performance* serve to summarize our musical knowledge in general and also to describe the development of Computer Music.

서양 음악은 작곡가에 의한 기획과 연주자에 의한 실행, 두 가지 모두에 중요성이 두고 있고, 따라서 음악은 종종 이 “두 가지” 성격의 표현형태가 있다: 연주자에 지시사항을 보여주는 악보와, 청자/소비자에게 ‘생산물product’로서의 연주소리를 전달하는 실시간 사운드나 녹음이다. (연극이나 영화, 일부의 건축물과 무용에도 같은 형태의 산물이 있다.) 고로, 컴퓨터 음악 연구의 세 번째 맥락은 상호작용, 악보의 표현적 해석, 재즈 즉흥연주, 연주 스타일에 이르는, 연주학적 탐구와 그 자동화가 되어야 할 것이다.

꽤 성급한 정리가 되겠으나, 나는 이 세가지 맥락: ‘사운드 생산, 음악적 표현, 연주의 실행’이 우리의 음악적 언어를 대체로 설명하고 컴퓨터 음악의 발전사를 이해하는데 도움이 될 것이라 믿는다.

The Impact of Technology

Throughout the history of Computer Music, the power of computers has grown at an exponential rate. It has been said that an order of magnitude difference is perceived as a *qualitative difference*, not just a numerical one, so we see a *qualitative difference* in computing every five to ten years. Each step through punched cards, time-sharing, personal computers, powerful laptops, cloud computing and mobile devices represents not just an increase in computing power but a new vista of opportunities for artists and researchers as well as a new framework within which we see problems and solutions.

Figure 1 illustrates growth in computing power over the history of Computer Music. The vertical axis is relative power, with a value of 1 assigned to the left-most year. The best measure of “computing power” is debatable, but all reasonable measures lead to the same conclusions. These graphs are purposefully plotted on a linear scale to show that, compared to today’s computers in 2020, even computers from 2000 seem to have no capability whatsoever. Many believe the growth rate is slowing, so I have plotted the next 30 years with a doubling time of 3 years rather than 2, which is roughly the doubling time since 1960. The horizontal axis on the right is the same, but the vertical axis is reset to so that today’s 1960’s-relative computing power (2.5E+09) in the first graph appears as 1.0 in the second graph. As this graph shows, todays computers, which power Internet search, face recognition, life-like computer graphics and of course digital music processing, will seem completely insignificant by 2050. To get even a glimpse of what is in store for the next 30 years, consider that 30 years ago, software sound synthesis was barely possible. (Dannenberg/ Mercer 1992) Or consider that the release of our personal computer audio editor Audacity in 2002 was still a decade away. (Mazzoni/ Dannenberg 2002)

테크놀로지의 영향

컴퓨터 음악의 역사 내내, 컴퓨터의 역량은 기하급수적인 속도로 성장했다. 어느 정도의 규모 차이는 단순히 수적인 것이 아닌 ‘질적 차이’를 유도하므로, 우리는 매 5년에서 10년마다 컴퓨터 사용에서의 ‘질적 차이’를 목도한다. 천공카드(종이테이프), 타임셰어링(동시사용), 개인컴퓨터, 강력한 노트북, 클라우드 컴퓨팅과 모바일 장비까지 각 단계에서 컴퓨터의 사용도와 성능이 단지 증가하는 것이 아니라 예술가와 연구자들에게 새로운 기회 전망을 보여주고, 문제점과 해결책을 가진 새로운 체계도 마련해 준다.

그림1은 컴퓨터 음악 역사 중 컴퓨팅 역량의 성장을 보여준다. 수직축은 상대적인 역량을 의미하며, 제일 왼쪽 시작 년도가 1의 값이다. “컴퓨팅 역량”에 대한 최적의 측정값은 논란의 여지가 있겠으나, 모든 합리적인 시도는 같은 결과를 가져온다. 이 그래프는 선형적 척도로 그려져, 2020년 오늘날의 컴퓨터와 비교하면 2000년 이후의 컴퓨터 조차도 아무런 성능이 없어 보일 정도이다. 많은 이들이 성장 속도가 둔화하고 있다고 여기는 것 같아서, 나는 향후 30년을 1960년 이래 대략 두 배의 값으로 성장했던 2년 단위 대신 3년마다 두배값이 되도록 그래프를 구성했다. 오른쪽 그래프는 수평축은 동일하나, 수직축은 왼쪽 그래프에서의 오늘날의 1960년 대비 성능값(2.5E+09)을 오른쪽에서는 1.0으로 재설정한 것이다. 이 그래프가 보여주듯, 인터넷 검색, 얼굴 인식, 실제 같은 컴퓨터 그래픽, 디지털 음악 처리도 물론 지원하는 오늘날의 컴퓨터는 2050년에는 완전히 하찮은 존재가 될 것 같다. 향후 30년간 어떤 일이 벌어질 지 어렴풋이라도 알고 싶다면, 30년 전 소프트웨어의 소리 합성이 거의 불가능했었다는 점을 생각해보라. (Dannenberg/ Mercer 1992) 혹은 개인용 컴퓨터에 오디오 편집하는 오데시티 Audacity의 2002년 출시가 10년이나 이후라는 점을 고려해보라. (Mazzoni/ Dannenberg 2002)

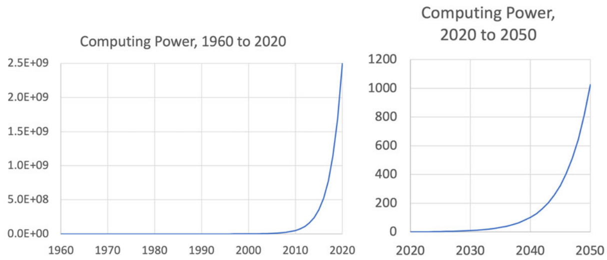

Figure 1. The growth of computing power has followed an exponential curve, doubling roughly every 2 years. Even if the doubling time slows to three years, today's computers will seem primitive within 20 or 30 years. The vertical axes represent relative power, with a value of 1 in 1960 (left) and 2020 (right).

그림1. 컴퓨팅 성능은 지수함수 곡선을 따라 성장하였으며, 매 2년마다 대략 두배가 된다. 두 배가 되는 시간을 3년으로 늦추어도, 오늘날의 컴퓨터는 20-30년 내에 원시적인 수준이 될 것이다. 수직축은 상대적인 성능값을 나타내며, 1960년(왼쪽)과 2020년(오른쪽)이 값 1을 갖는다.

One thing seems certain: We can imagine many developments in terms of today's technologies and devices, but the technologies of the future will be *qualitatively* different from what we have now. We will not continue to view problems in the same way. We can think about what we can do with faster computers, but it is much harder to imagine what new forms computing will take when computational power increases by orders of magnitude. We are probably better off to think in terms of musical imperatives.

한 가지는 확실해진 듯하다: 우리가 오늘날의 기술과 장비에 관하여 여러 발전상을 상상해본다 하더라도, 미래의 기술은 지금의 것과는 '질적으로' 다른 것이 될 것이다. 우리가 문제점을 똑같은 방식으로 대하는 것은 계속되지 않을 것이다. 보다 빨라진 컴퓨터로 무엇을 하게 될지 예상할 수 있을지라도, 자릿수가 다른 속도로 컴퓨팅 성능이 발전한다면 새로운 컴퓨팅이 어떤 모습일지 상상하는 것은 훨씬 어려울 것이다. 음악적 책무에 입각하여 생각해보는 것이 아마 더 나을지도 모른다.

A Brief History of Computer Music

컴퓨터 음악의 간략한 역사

To further explore these threads of sound generation, music representation, and performance, I would like to consider them in the context of some historical Computer Music developments. This is not meant to be a complete history by any means, but it will help set the context for thinking about possible futures.

이렇게 사운드 생산, 음악적 표현, 연주 실행으로 이어지는 맥락을 더 깊게 탐구해보기 위하여, 나는 컴퓨터 음악 역사의 맥락에서 몇몇 발전상을 짚어보고자 한다. 어떻든 이는 완전한 역사를 의미하지는 않지만, 미래 가능성을 예견할 만한 문맥을 마련해줄 수 있을 것이다.

Early Computer Music

초기의 컴퓨터 음악

In the earliest years of Computer Music, essentially all computers were mainframe computers that were programmed by submitting a stack of instructions on punched cards and receiving results in print or on magnetic tape. The first music sound generation software is exemplified by Max Mathew's Music *N* programs (Mathews M. 1969), which already neatly capture the notions of sound and score (representation) in the "orchestra language" and the "score language." The former was designed to express digital signal processing needed to create *sound*, and the latter was a separate *music representation* language designed to express sequencing and control parameters for those signal processing operations.

컴퓨터 음악의 초창기 몇 년간은, 모든 컴퓨터가 종이테이프에 한 뭉치의 지시사항을 입력하여 제출하면 인쇄물이나 마그네틱 테이프로 그 결과를 받아 프로그래밍되는 메인프레임 컴퓨터였다. 첫 음악 사운드를 생산하는 소프트웨어는 맥스 매튜스의 뮤직 엔N의 프로그램들이었으며(Mathews M. 1969), 일찍이 사운드와 악보(표현)를 "오케스트라 언어"와 "악보 언어"로 잘 담아내는 것이었다. 전자는 "사운드"를 만드는데 필요한 디지털 신호처리를 전달하도록 만들어졌고, 후자는 그러한 신호처리를 실행하도록 시퀀싱과 파라미터들을 조절할 수 있게 고안된 별도의 "음악적 표현" 언어로 만들어졌다.

Real-Time Digital Instruments

As soon as integrated circuits achieved enough power to perform basic audio signal-processing tasks in real time, digital instruments began to appear. Research systems such as the Dartmouth Digital Synthesizer (1973) and the Bell Labs Hal Alles Synthesizer (1976) led to commercial systems such as the CMI Fairlight and New England Digital Corporation Synclavier, which were soon followed by mass-produced instruments such as the Yamaha DX7 (1983). Viewed from the perspective of *performance* and the understanding of exponential growth in computer power, these developments were inevitable, even though keyboard instruments were *qualitatively* nothing like the programmed mainframe and minicomputers in use up to that time.

Interactive Systems

The combination of affordable real-time digital synthesis, the interface possibilities of MIDI, and the introduction of personal computers, all coalescing more-or-less in the 1980's, enabled a new direction in computer music: real-time musical interaction with computers. (Rowe 1992; Winkler 1998) Many musicians developed interactive systems: Composed Improvisation (Eigenfeldt 2007) by Joel Chadabe, Laurie Spiegel's "Music Mouse" for personal computers (1986), The Sequential Drum by Max Mathews and Curtis Abbot (Mathews M. V. 1980), *Voyager* (Lewis 2000) by George Lewis, Ron Kuivila's compositions with Formula (Anderson/ Kuivila 1990), and David Wessel's compositions with MIDI-Lisp (Wessel/ Lavoie, P./ Boynton, L./ Orlarey, Y. 1987) are just a few of many experimental works. In that time period, I designed the CMU MIDI Toolkit in 1984 (Dannenberg 1986), inspired by Doug Collinge's *Moxie* (Collinge 1985) language, and created *Jimmy Durante Boulevard* in a collaboration with Georges Bloch and Xavier Chabot (1989).

Interactive Systems brought compositional algorithms, previously only used for non-real-time composition, into the world of performance. Just as real-time synthesizers can be seen as joining digital sound and performance, interactive systems represent the union of music representation and composition with performance. As mentioned earlier, this created a new mode of composition. The composer specifies a piece not so much by writing notes as by writing interactions. These interactions continuously constrain and guide the sensitive musician to carry out the composer's plans. At the same time, the improviser is free to inject spontaneous and virtuosic elements that the composer might not have imagined. In the most successful work, a previously unknown and exciting synergy is achieved.

실시간 디지털 악기들

집적회로로 기본적인 오디오 신호처리 업무가 실시간으로 가능하게 되자 곧 디지털 악기들이 나타나기 시작했다. 다트머스 디지털 신서사이저(1973)와 벨 연구소 할 알레스 신서사이저(1976) 같은 연구 시스템에서 페어라이트 CMI와 뉴잉글랜드 디지털사 신클라비어와 같은 상업적 시스템으로 연결되며, 곧이어 야마하 DX7(1983) 같은 대량생산되는 악기도 나오게 되었다. 컴퓨터 성능의 기하급수적 성장에 대한 이해와 함께 '연주실행'의 견지에서 보았을 때, 키보드 악기들이 당시에 사용되었던 프로그램된 메인프레임 컴퓨터나 미니 컴퓨터에 '질적으로' 미치지 못했다 할 지라도, 이러한 발전은 불가피했다.

인터랙티브 시스템들

저렴한 가격의 실시간 디지털 합성기기, 미디의 인터페이스 가능성, 그리고 개인용 컴퓨터의 등장, 이들이 정도의 차는 있지만 1980년대 합쳐지면서 컴퓨터 음악의 새로운 동향을 만들어냈다: 즉 컴퓨터로 실시간 음악적 상호작용이 가능하게 되었다. (Rowe 1992; Winkler 1998) 많은 음악가들이 상호작용 시스템을 개발했다: 조엘 차다베 Joel Chadabe 의 작곡된 즉흥작품(Eigenfeldt 2007), 로리 슈피겔 Laurie Spiegel 의 개인용 컴퓨터를 위한 "뮤직 마우스"(1986), 맥스 매튜스와 커티스 아보트 Curtis Abbot 의 연속적 드럼 The Sequential Drum (Mathews M. V. 1980), 조지 루이스 George Lewis 의 '보이저 *Voyager*'(Lewis 2000), 론 쿠이빌라 Ron Kuivila 의 포뮬라(공식)로 쓴 작품(Anderson/ Kuivila 1990), 데이비드 웨슬 David Wessel 의 미디-리스프 MIDI-Lisp 로 쓴 작품(Wessel/ Lavoie, P./ Boynton, L./ Orlarey, Y. 1987)은 많은 실험적 작품들 중 일부일 뿐이다. 그 기간에 나는 더그 콜린지 Doug Collinge 의 막시 *Moxie*(Collinge 1985) 언어에 영감을 받아 1984년 시엠유 미디도구세트 CMU MIDI Toolkit 를 개발했고(Dannenberg 1986), 조르주 블로흐 Georges Bloch, 자비에 샤보 Xavier Chabot(1989)와 함께 협업하여 지미 듀란트 블러버드 *Jimmy Durante Boulevard* 를 창작했다.

상호작용 시스템이 이전에는 비실시간 작곡으로만 사용되었던 작곡 알고리즘을 공연 무대 위로 올려 놓았다. 실시간 신서사이저가 디지털 사운드로 공연 연주에 합류하게 된 것처럼, 상호작용 시스템은 음악적 표현과 작곡 과정, 공연 연주가 연합되었음을 의미한다. 앞서 언급했듯이, 이는 새로운 작곡 양식이 탄생한 것이다. 이제 작곡가는 음표를 기보하는 것이 아니라 상호작용을 만들어 한 작품을 완성한다. 이 상호작용 시스템이 작곡가의 의도를 실행하려 신경쓰는 연주자에게 지속적인 제한과 안내를 제공한다. 이때 즉흥연주자는 자유롭게 작곡가가 계획하지 않은 자발적이거나 기교적인 요소들을 주입할 수 있다. 가장 성공적인 경우, 이전에 없었던 새롭고 흥미로운 동반 상승 효과를 얻을 수 있다.

Computer Accompaniment

Another approach to interaction is based on the traditional model of chamber music where notes are determined in a score by the composer, but musicians perform the score with expressive timing. In the Computer Music world, composers were drawn to the possibilities of computation, which fixed music precisely in time, but the only way to combine that approach with live performance was to play along with a fixed recording. There was an obvious disconnect using fixed media in live performance, ignoring the well-developed ideas of expressive performance in chamber music. In 1983, I began to experiment with algorithms, and I built a complete working accompaniment system in 1984 that could listen to my live trumpet performance, follow along in a score, and synthesize another part in real-time, synchronizing with the soloist. (Dannenberg 1985) Similar work was introduced around the same time by Barry Vercoe. (1985) Later, my computer accompaniment work was used to create the Piano Tutor, an intelligent tutor for teaching beginning piano students (Dannenberg, et al. 1990), and computer accompaniment was commercialized in what is now SmartMusic and used by hundreds of thousands of students. Work on score following and collaborative performance is still an active topic today.

컴퓨터 동반 연주

상호작용에 대한 다른 관점으로, 전통적인 실내악에서 작곡가가 악보에 음을 결정해두지만 연주자가 이를 표현적인 시간 조절을 하며 연주하는 것에 착안한 것이 있다. 컴퓨터 음악에서는, 고정된 음악으로서 정확한 시간으로 연주하는 계산처리 능력이 작곡가들에게 꽤 매력적이었으나, 실제 연주자들과 함께 연주하려면 그들이 고정매체를 따라 가는 것 외에는 다른 방법이 없다. 전통 실내악에서 잘 발전된 연주 표현 기법들은 무시된 채, 연주자의 실시간 연주와 고정 매체를 사용한 음악 사이에 명백한 단절이 존재하는 것이다. 1983년 나는 알고리즘으로 실험을 시작하여, 1984년 나의 트럼펫 연주를 듣고 악보를 따라 새로운 파트를 실시간으로 합성하며 독주 연주자와 동반으로 연주가 가능한 완전한 형태의 동반연주 시스템을 완성하였다. (Dannenberg 1985) 비슷한 시기에 배리 베르코Barry Vercoe도 이와 유사한 시스템을 발표하였다.(1985) 이후 나의 컴퓨터 동반연주 시스템은 피아노를 처음 시작하는 학생들을 가르치는 지능 튜터인 피아노튜터Piano Tutor를 만드는데 사용되었고 (Dannenberg, et al. 1990), 컴퓨터 동반 연주는 현재 스마트뮤직SmartMusic이라는 이름으로 상업화되어 수십만의 학생들이 사용하고 있다. 악보를 따라가며 협동 연주하는 것에 대한 개발은 지금도 여전히 유효한 연구 주제이다.

Human Computer Music Performance

Computer Accompaniment distilled the basic idea of following a score and synchronizing performance, but in music, there are many more problems related to collaboration. This came to my attention around 2005 when I was playing in a rock band's horn section. As the only trumpet, and not a strong lead player, I began to think how much better it would be if I were the *second* trumpet alongside a great high-note player. It did not take long to imagine I could use my computer accompaniment techniques to create a virtual musician for the band. However, I soon realized that the band did not always follow a score strictly from beginning to end. Also, horns do not play all the time, so how would the virtual player enter precisely in time and in tempo without following a leader? A virtual player might "listen" to the keyboard player, but the keyboardist improvises chord voicings and rhythms, so there is no detailed score to follow there.

These and other problems led me to think about musical collaboration much more broadly than before. Synchronization is achieved not only by following scores, but by following the beat, following chord progressions, visual cues, following conductors, becoming the leader, and combinations of these things. Parts are specified by traditional scores, lead sheets, drumming or percussion styles, and analogy ("I want you to play this part the way Bill Evans might do it.") In other words, the broader goal is not simply an "adaptive sequencer" that synchronizes to a pre-determined stream of notes, but an *artificially intelligent musical partner*.

휴먼 컴퓨터 음악 퍼포먼스

컴퓨터 동반 연주는 악보를 따르며 연주에 합류한다는 기본 개념을 뽑아낸 것이지만, 실제 음악에서는 합주에 연관된 더 많은 문제점들이 존재한다. 내가 2005년 즈음 록밴드의 금관 파트를 맡아 연주하면서 이 점에 관심을 두게 되었다. 주도적인 연주자가 아닌, 그저 트럼펫 주자로서, 내가 훌륭한 고음파트 연주자와 잘 동반하는 트럼펫 '제2주자'라면 얼마나 더 나을 수 있을까 생각하기 시작했다. 오래 지나지 않아 나는 컴퓨터 동반연주 기술을 사용하여 밴드를 위한 가상 연주자를 만드는 상상을 하게 되었다. 하지만, 나는 곧 밴드가 언제나 처음부터 끝까지 악보를 정확하게 따라 연주하지 않는다는 사실을 깨달았다. 게다가, 금관파트가 계속해서 연주하지 않는데, 어떻게 가상 연주자가 지휘도 없이 제 시간에 제 빠르기로 맞추어 합류할 수 있을까? 가상 연주자가 키보드 연주를 "듣는" 것은 가능하더라도, 키보드 연주자가 화음과 리듬을 즉흥으로 연주하는데 이를 따라갈 만큼 상세히 기보된 악보는 없었다.

이런 저런 문제점들로 나는 이전보다 훨씬 더 폭넓게 음악 합동 연주에 대하여 생각하게 되었다. 일치된 연주는 악보를 따라가는 것뿐 아니라 박자를 따라, 화음 진행을 따라, 시각적 신호로, 지휘를 따라, 리드를 하면서, 이것들이 모두 결합되었을 때 가능해지는 것이다. 전통적인 악보, 선율 악보(리드 시트), 드럼이나 타악기 패턴, 유추("빌 에반스가 연주하듯 이 부분을 연주하시오."와 같은 말)로 각 파트를 명시한다. 다시 말해, 단순히 미리 정해진 일련의 음들을 동시에 연주하는 "순응적인 시퀀서"가 아니라, "인공지능적인 음악적 파트너"라는 더 폭넓은 목표를 가져야 한다는 것이다.

We can see related work in laptop orchestras, networked music performance, and artificial intelligence for composition. These are all approaches that use technology for human-human and human-computer *music collaboration*.

이와 연관된 작업을 노트북 오케스트라, 네트워크로 연결된 음악 공연, 작곡하는 인공지능에서 볼 수 있다. 이들은 모두 인간 대 인간과 인간 대 컴퓨터 간의 음악 협동 작업에 사용하는 테크놀로지의 접근 방식이다.

Interlude

Let us try to sum up some ideas of this brief discussion. Computer Music has ridden a wave of exponential growth in computing power to get us where we are today. Much of our progress could never happen without integrated circuits, powerful computers and the whole information age (for example, only the pervasive adoption of computing in daily life could drive down price of billion-transistor processors to affordable levels.) However, the main directions of Computer Music can be seen as an attempt to reproduce and then extend traditional music concerns in three areas: sound, music representation, and performance.

We have discussed an historical progression in which researchers explored the production of sound, music representation and control, real-time interaction, computer accompaniment, and collaboration in general. The future will bring unimaginable computing technologies and with them multiple qualitative changes in the way we think about or experience computing. However, our principal musical concerns are likely to be the same ones humans have pursued for centuries if not millennia, so with that assumption let us consider some implications for the future.

막간글

지금까지의 짧은 논의에서 나왔던 생각들을 정리해보자. 컴퓨터 음악은 오늘날의 우리에게 있는 모습대로 기하급수적으로 성장한 컴퓨터 파워의 물결을 타고 전진했다. 우리가 이룬 진보는 집적회로나 고성능의 컴퓨터, 온전한 정보의 시대 없이는 결코 이룰 수 없었을 것들이다. (예를 들어, 일상 생활의 전반에서 컴퓨터를 적용해야만 십 억 개에 달하는 트랜지스터 프로세서의 가격을 적당한 수준으로 낮출 수 있다.) 그러나, 컴퓨터 음악의 주요 방향은 사운드, 음악적 표현, 연주 실행의 세 영역에 대한 전통적인 음악적 요구조건을 재생산하고 확대하려는 시도에 있다.

우리는 역사 속 발전과정에 대하여 논의하였는데, 소리를 생성하고, 음악적 표현과 제어, 실시간 상호작용, 컴퓨터 동반 연주와 협동 작업에 대한 연구가 그 전반적인 것들이었다. 미래는 상상할 수 없을 정도로 컴퓨터 기술이 발전할 것이고, 이에 따라 우리가 컴퓨터에 대해 생각하거나 경험하는 방식에서도 다양한 질적인 변화가 일어날 것이다. 하지만, 음악에 대한 우리의 주요 관심사는, 인류가 수천년은 아니여도 수세기동안 추구해왔던 것과 다름없을 것으로 보이는데, 따라서 이를 전제로 미래에 대한 몇 가지 예측을 해보자.

The Future of (Computer) Music

One way to conceptualize the whole of musical concerns is illustrated in Figure 2. Here we see “Instruments” as the world of sound generation and processing. While instruments produce sounds, musicians organize sounds into phrases, and there is much work to be done to understand phrases (more on this below). Phrases (or, in some terminologies, “musical gestures”) are assembled to form compositions. Compositions are performed, giving rise to many concerns of collaboration and coordination. Let us consider each of these realms separately.

(컴퓨터) 음악의 미래

음악에 대한 관심사 전체를 개념적으로 정리한 것을 그림2에 나타내었다. 여기서 “악기instruments”는 소리를 생성하고 처리하는 하나의 세계를 뜻한다. 악기가 소리를 만드는 동안, 음악가는 소리를 조합하여 악구phrase로 만드는데, 이 악구를 이해하려면 많은 과정이 필요하다 (이에 대한 더많은 정보를 다음 쪽을 참고하라). 악구(혹은, 다른 용어로는 “음악적 제스처”)가 조립되어 작곡 작품을 형성한다. 작품이 연주되면서, 합주나 협업에 대한 여러 문제점들이 생기게 된다. 각각의 영역을 개별적으로 고려해보자.

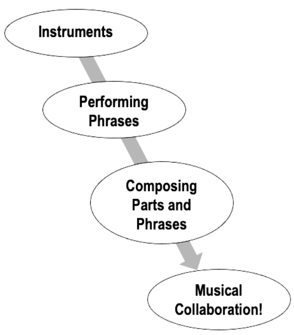

Figure 2. Schematic of Computer Music areas of concern.

그림2. 컴퓨터음악의 중요한 영역을 도식으로 나타낸 것.

Instruments

Even after decades of research, instrument modeling remains elusive. The non-linear, 3-dimensional physics of acoustic instruments are complex (Bilbao 2009), and our perceptual abilities are exceptionally refined, making even slight imperfections quite apparent. Musicians take many years to learn to control acoustic instruments, and without control, even real acoustic instruments do not make interesting musical tones. It seems that in the future, orders of magnitude more computation will be applied to acoustic instrument simulation as well as to machine learning to discover how to control them to produce musical results. From there, new possibilities will emerge to artistically manipulate "physics" in our simulations to design new instruments and new sounds, informed but not limited by real acoustics. Spectral synthesis models based on computational models of perception are also a promising direction for new sound creation.

Another interesting direction is the development of physical robotic instruments such as those explored by Trimpin, Eric Singer, Ajay Kapur and others. I helped Ben Brown and Garth Zeglin construct a high-performance robot bagpipe player, McBlare, at Carnegie Mellon University. (See Figure 3.) The "robot effect" described earlier suggests that we should pay attention to robots, and particularly *humanoid* robots such as Waseda's flute playing machine WF-2 (Solis, J., et al. 2006). Just as musicians have been able to use computers and sensors developed for other applications, I expect humanoid robots created with other purposes in mind will offer very engaging modes of musical performance.

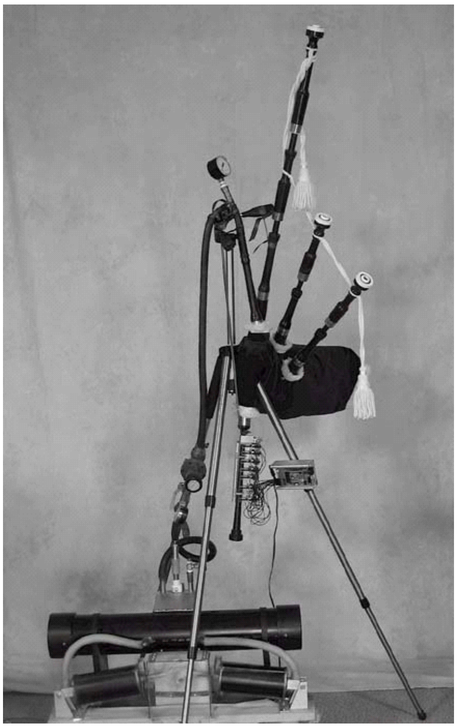

Figure 3. McBlare, Carnegie Mellon's robotic bagpipe player.

악기

수십년의 연구에도 불구하고, 악기 모델화는 여전히 실행이 어려운 단계이다. 음향 악기의 비선형, 3차원적 물리학은 복잡하고(Bilbao 2009), 사소한 결함도 명확히 느껴질 만큼 우리의 지각능력은 유난히도 정교하다. 음악가들이 악기를 다루는 법을 배우는 데는 수년이 걸리고, 제어 능력이 없이는 실제 악기로도 그럴싸한 음악적인 소리를 만들기 어렵다. 미래에는 음악적 결과를 내기 위해 어떻게 악기를 제어해야 하는지 알아내기 위해 훨씬 많은 계산처리 과정이 기존 악기의 시뮬레이션이나 머신 러닝에 적용될 것이다. 거기서부터, 새로운 악기와 새로운 사운드를 만드는 시뮬레이션 과정에서 "물리학"을 예술적으로 통제할 수 있는, 실제 음향학에 국한되지 않은 새로운 사실과 함께, 새로운 가능성이 나타나게 될 것이다. 인지적 연산 모델에 기반한 스펙트럼 합성 모델도 역시 새로운 사운드를 만드는데 유망한 방향의 연구 분야이다.

또 하나 흥미로운 분야는 트림핀Trimpin, 에릭 싱어Eric Singer, 아제이 카푸르Ajay Kapur 외 다수가 시도한 것과 같은 실체적 로봇 악기의 개발이다. 나는 카네기멜론 대학에서 벤 브라운Ben Brown과 가드 제글린Garth Zeglin을 도와 고성능 로봇 백파이프 연주자인 맥블레어MacBlare를 제작했다. (그림3을 보라.) 앞서 설명한 "로봇 효과"는 우리가 로봇에, 특히 와세다의 플룻 연주 기기 WF-2 (Solis, J., et al. 2006)와 같은 '인간형' 로봇에 주의를 기울여야 한다는 것을 알려준다. 음악가들이 다른 응용 분야를 위해 개발된 컴퓨터와 센서를 사용할 수 있게 된 것 처럼, 나는 다른 목적을 염두에 두고 만들어진 인간형 로봇이 아주 매혹적인 음악 연주 스타일을 만들어낼 날이 오길 기대한다.

그림3. 맥블레어, 카네기멜론의 로봇식 백파이프 연주자.

Phrases

Many years ago, the mantra “sampling is dead” was frequently heard among computer music researchers. The basic idea of samples is to record “notes” of instruments and play them back on demand. If a violin plays a range of 4 octaves at 10 different dynamic levels, that is about 500 sounds, assuming we can find reasonable ways to control duration and simulate vibrato. In the early days of limited memory, even having 50 very short samples that required “looping” to extend them was already expensive, so it seemed hopeless to achieve high quality through sampling. Over time, however, memory prices came down, so sample libraries could add longer samples and many variations of articulation, bow position, and even extended techniques. It seems that our predictions were premature.

However, expressive continuous control is still a problem for samples, and here is where *phrases* enter the picture. My work in the 90’s showed that the details of individual notes are highly dependent upon context. (Dannenberg/ Pellerin/ Derenyi 1998) For example, a slurred transition between two trumpet notes is entirely different from an articulation where the air is briefly stopped by the tongue, and details of the transitions are also affected by the pitches of the notes. Thus, *phrases* are critical units for musical expression and even timbre, yet they have been largely ignored.

In the future, either sampling will have to “die” or expressive phrases available to string and wind players will disappear from electronic music. Well, at least we will have to solve the problem of sample selection from ever-growing libraries that now reach gigabytes, and we will have to do something about the rigidity of recorded samples once they are selected. There is certainly room for more research here. As storage limits disappear, the real limits of sampling are becoming apparent, and old solutions such as work from my lab on Spectral Interpolation Synthesis (Dannenberg/ Derenyi 1998) and other work on physical models are re-emerging. Eric Lindemann’s Synful Orchestra synthesis technology is a commercial example of a more phrase-based and non-sample-based approach.

Composing in the Future

Recently, there has been a resurgence of work on automated computer music composition. Every innovation in Artificial intelligence – rule-based expert systems, constraint systems, production systems, Bayesian approaches, neural networks and now various kinds of deep learning – has been applied to model the compositional process. We can expect this trend to continue.

악구

수 년 전, ″샘플링은 끝났다″라는 주문이 컴퓨터음악 연구자들 사이에서 자주 들렸다. 샘플의 기본 개념은 악기의 ″음″들을 녹음하고 필요에 따라 그것을 재생하는 것이다. 바이올린이 네 옥타브의 음역을 열 단계의 셈여림으로 연주하면 약 500개의 소리가 되고, 우리는 이를 적당한 방법으로 길이를 조절하고 비브라토를 적용할 수 있을 것이다. 메모리가 제한적이었던 초기 시절에는, 오 십 개의 매우 짧은 샘플 조차도 필요한 만큼 ″연속재생″하여 이들을 늘이는데에 이미 많은 비용이 소요되었기 때문에, 샘플링으로 고품질의 소리를 얻는 것은 기대하기 어려웠다. 그러나 시간이 흘러, 메모리 가격이 낮아지고, 샘플 저장소에 더 긴 샘플과 다양한 아티큘레이션, 활 포지션, 여러 확장된 기법의 소리를 추가할 수 있게 되었다. 우리의 예측은 시기상조였던 것으로 보인다.

그런데, 지속적인 표현 제어는 여전히 샘플의 문제점이고, 여기가 바로 ‘악구’가 등장해야 하는 지점이다. 90년대 내 연구에서 각 개별 음의 세세한 요소들이 문맥에 따라 민감하게 변화함을 보여준다. (Danne nberg/ Pellerin/ Derenyi 1998) 예를 들어, 이음줄로 연결된 두 개의 트럼펫 음은 텅잉(혀)으로 소리가 끊어지는 기법과는 전혀 다르게 표현되며, 두 음이 연결되는 지점 또한 음의 높이에 따라 다르게 표현된다. 따라서, ‘악구’에서는 음악적인 표현법과 음색도 중요한 결합 요건이 되지만, 대부분 이러한 점에 주의를 기울이지 않는다.

미래에는, 전자 음악에서 샘플링이 ″무용지물″이 되거나 관현악기 연주자들의 표현적인 악구가 사라져야 할 것이다. 아마, 적어도 현재 기가바이트에 달하는 전례없이 성장하는 저장소로 샘플 선택의 문제점을 해결하고, 일단 선택된 녹음 샘플의 비유연성에 대해 무슨 대책이라도 세워야 할 것이다. 여기 더 많은 연구를 위한 여지는 확실히 있다. 저장의 한계가 없어지면, 샘플의 진짜 한계점이 분명해지고, 내 실험실에서의 스펙트럼 보간 합성에 대한 연구(Dannenberg/ Derenyi 1998)나 다른 물리적 모델에 대한 연구의 지난 해결책들이 다시 부상하게 될 것이다. 에릭 린드만Eric Lindemann의 신풀Synful 오케스트라 합성 기술은 보다 악구에 기반하며 샘플로 접근하지 않는 상업적 예시가 된다.

미래의 작곡하기

근래에, 컴퓨터 음악 작곡 자동화에 대한 연구가 다시 부활하고 있다. 모든 인공지능에서의 혁신 – 규칙기반의 전문가 시스템, 제한적 시스템, 생산적 시스템, 베이지안 접근법, 신경망 네트워크와 현 시점의 다양한 딥 러닝 – 이 작곡 과정을 모델화하는데 응용되고 있다. 이러한 경향은 지속될 것으로 보인다.

In my view, recent work, while technically impressive, has been musically disappointing. Perhaps the success of deep networks in other areas has misled researchers into putting too much faith in data-driven learning methods. Composition is regarded by many as a problem of imitation: Train a machine learning algorithm with examples of music and try to generate something similar. But how many composers aim to (merely) imitate? Composers have not played a large role in recent research, and in many ways, earlier research by composers produced more musical results. Composers have a better understanding of what composition is really about, and it seems that deep learning is no substitute (yet) for human understanding. One possible direction for the future is the development of a real science of composition involving investigations in neuroscience, models of information and communication, participation by composers, and listener studies. Then again, with another 10 years' growth in computational power and the qualitative changes it will bring, we could see a revolution in scientific practice that makes even these ideas seem short-sighted.

In any case, there is clearly room for more research here, and we can expect to see a slow and steady progression beginning with simpler tasks such as making drum loops, harmonization and creating musical textures. From there, perhaps we will develop composition systems that work well in highly constrained settings: improvising over a set meter and chord progression, composing percussion tracks or bass lines given a set of parts, or generating call-and-response melodic units. Eventually, we will come to understand higher-level structures, music anticipation and surprise, and music design to the point we begin to see truly original musical creations by computer.

Performance in the Future

Live performance with computers is still nascent. There are some stunning pieces in the repertoire, and plenty of techniques from composed improvisation to computer accompaniment, but let us be honest and critical here. Interactive systems are largely based on triggers to step through fixed sequences, simple responses to simple input patterns, or just random but interesting choices. Machines have little understanding of tempo, timbre, form, anticipation or surprise, and it is as much a stretch to call computers true collaborators in 2020 as it would be to call the pianoforte a musical collaborator in 1750.

Computer accompaniment systems coordinate with musicians at a finer time scale by tracking performances note-by-note. Work with Gus Xia shows that deeper musical understanding can dramatically improve prediction in collaborative performance. (Xia/ Wang/ Dannenberg/ Gordon 2015) So far, computer accompaniment systems are quite shallow and fail to adapt as collaborators might. These systems are also brittle, typically applying only one method of listening or processing input, whereas musicians have a much richer repertoire of techniques including score analysis, phrase analysis, entrainment to beats, leading and following, giving and accepting visual cues, source separation, and exceptional musical awareness.

내 생각에, 최근 작업들은 기술적으로는 돋보이나 음악적으로는 실망스럽다. 다른 분야에서 깊이있는 성공적 네트워크 작업이 아마 연구자들에게는 데이터 기반의 러닝 방식에 지나친 믿음을 주었을 것 같다. 작곡은 많은 이들이 모방의 범주로 받아들여져서: 음악작품을 예시로 삼아 머신 러닝 알고리즘를 돌리면서 그와 비슷한 결과를 얻으려 한다. 그러나 얼마나 많은 작곡가들이 (단지) 모방에 그치고자 하는가? 작곡가들은 최근 연구에서 큰 역할을 하지 못했으며, 여러 관점에서 오히려 초반기 작곡가들의 연구가 보다 음악적인 결과를 얻었다. 작곡가들은 작곡의 본질에 대해 나은 이해력을 갖고 있고, 딥 러닝이 (아직은) 사람의 이해에 미칠 대체물이 될 수는 없는 것 같다. 미래에 가능할 만한 분야는 신경과학적 조사, 정보와 커뮤니케이션을 위한 모델, 작곡가의 참여, 청중 연구와 연관된 현실 과학적 작곡의 개발이다. 그러하여 다시 말하면, 앞으로 올 향후 십년 간 처리능력과 질적 변화의 성장으로, 이러한 예측조차 근시안적으로 만들만한 과학적 실체의 혁명을 볼 수 있을 것이다.

어떠한 경우에든, 여기 더 많은 연구의 여지가 분명히 있으며, 우리는 드럼 루프를 만들거나, 화음을 쌓고 성부 짜임새를 구성하는 것과 같이 보다 간단한 작업에서 시작하여 더디지만 꾸준히 진행해 나가야 한다. 거기서부터, 박자 변화와 화음 진행에 따라 즉흥 연주를 하고, 전체 짜임새에 어울리는 타악기 파트나 베이스 성부를 만들고, 선율을 주고받으며 작곡하는 식의, 높은 수준으로 제한된 설정도 잘 처리할 수 있는 작곡 시스템을 만들어낼 수 있을 것이다. 결국, 우리가 더 복잡한 구성, 음악적 기대와 서프라이즈, 뮤직 디자인을 제대로 이해하게 될 때가, 진정으로 독창적인 컴퓨터 작곡을 하는 시점이 될 것이다.

미래의 연주

컴퓨터로 하는 라이브 공연은 아직 초기단계이다. 작품목록에 멋진 곡들이 있고 즉흥 프로그램부터 컴퓨터 동반 연주까지 많은 기술들이 있긴 하지만, 여기서는 솔직하게 비판해보자. 상호작용 시스템은 대체로 트리거를 사용하여 정해진 시퀀스들을 차례로 실행하거나, 간단한 입력 패턴에 간단한 반응을 연결하고, 흥미로운 어떤 것들을 무작위로 선택하는 방식이다. 기계는 빠르기나 음색, 형식, 음악적 기대감과 서프라이즈를 잘 모르는데, 1750년 피아노를 음악적 협력자라 불렀던 것처럼 컴퓨터는 2020년 진정한 협력자라 부르는 것은 무리가 있다.

컴퓨터 동반연주 시스템은 연주자가 음표 하나하나 연주하는 것을 미세한 시간 단위로 트래킹하면서 이루어진다. 거스 시아와의 동반연주 작업에서, 음악에 대한 더 깊은 이해를 바탕으로 추정하였을 때 결과가 극적으로 향상됨을 알 수 있었다. (Xia/ Wang/ Dannenberg/ Gordon 2015) 지금까지의 컴퓨터 동반연주 시스템은 매우 얕은 정도로, 협력자의 수준으로 받아들여지지는 못했다. 이 시스템은 취약하기도 한데, 실제 음악가가 악보와 악구를 분석하고, 비트를 타고, 리드하거나 따라가고, 시각적 신호를 주거나 받고, 음원을 분리하고, 특별한 음악적 인식을 하는 등 매우 다각적인 테크닉을 구사하는데 반해, 이 시스템은 듣거나 입력을 처리하는 한 가지 방식만 적용 가능하다.

One of my research directions is to enable human-computer collaboration in the performance of beat-based music, an area largely ignored by Computer Music research. It is not clear who would actually perform with such systems, but it is an interesting challenge. In any case, we have a long way to go to develop more computational music understanding for live collaborative music performance.

비트 기반의 음악을 인간과 컴퓨터로 함께 연주 공연하는 것이 내 연구 주제 중 하나인데, 이 영역은 컴퓨터 음악 연구에서 별로 관심을 두지 않는 곳이다. 이러한 시스템을 실제로 누가 쓰게 될 지는 모르지만, 흥미로운 도전이라 여긴다. 어쨌든, 컴퓨터와 실시간으로 협동하여 음악을 공연하는데 필요한 보다 전산적인 이해력을 갖추려면 갈 길이 멀다.

Non-Traditional Music

In considering music through the lens of historical constants, we should not conclude that computers are simply a way to preserve past traditions or to electronically reproduce the past. This is certainly what we have seen in the first commercial waves of computer music technology, including synthesis of acoustic instrument sounds, electronic keyboards for performance, and music representations such as MIDI, which is based on traditional concepts of notes, scales and beats.

Even though I believe computer music developments and perhaps even the future can be seen in traditional terms of sound, representation, and performance, this does not mean that we are stuck with traditional sounds, conventional representations, or the “individual musicians control independent instruments in coordinated, co-located ensembles” approach to music performance. Many of these traditions were being challenged even before computing entered the scene.

Consider Conlon Nancarrow’s “Study for Player Piano No. 1” (1951), an early work in a series of compositions that inspired many computer music composers, or Krzysztof Penderecki’s “Threnody to the Victims of Hiroshima” (1960), which uses traditional instruments (orchestral strings) but non-traditional playing techniques, pitches, rhythmic concepts, and arguably has no sounds identifiable as “notes.” Many 20th Century works including these established foundations for Computer Music composers. Nevertheless, these works can still be seen in terms of instruments (the player piano or string orchestra), representation (piano rolls, graphical scores) and performance (in these examples, both fairly traditional).

Composers of the early 20th Century “broke the rules” to find a way forward, and computers give us even more opportunities to redefine the parameters, conventions and practice of music. This trend has been amplified by the democratization of music creation and distribution. With the low cost of computing, music creators are no longer dependent upon the power structures of orchestras, opera companies, or even studios to realize their ideas. The Internet has created new ways to reach audiences. Thus, we are now in a period of great exploration that seems likely to continue.

비전통적 음악

역사적 불변이라는 렌즈로 음악을 볼 때, 컴퓨터를 단순히 과거의 전통을 보존하는, 혹은 전자적으로 과거를 재생산하는 수단으로 결론지어서는 안된다. 이는 음과 음계, 박자 같은 전통적인 개념에 기반하여 음향 악기 사운드를 합성하고, 공연에서 전자키보드를 쓰고, 미디 같은 음악적 표현법을 활용하면서 컴퓨터 음악 기술이 처음으로 상업적인 파도를 탔을 때 확실히 본 것이다.

나는 컴퓨터 음악의 발전, 그리고 그 미래도 사운드와 표현, 연주라는 전통적인 요구조건에 달려있다고 믿지만, 이것이 전통적인 사운드와 기존의 표현기법, 그리고 “개별 연주자들이 독립적으로 자신의 악기를 연주하며 동일한 공간에 위치한 앙상블과 협력하는” 방식의 음악 연주에 머물러야 한다는 뜻은 아니다. 이러한 전통 중 많은 부분은 컴퓨터가 등장하기 전에 이미 위기를 겪고 있었다.

콘론 낸캐로우의 “자동피아노를 위한 스터디 1번”(1951)은 많은 컴퓨터음악 작곡가들에게 영감을 준 시리즈 작품의 초기작이며, 크시슈토프 펜데레츠키의 “히로시마 희생자를 위한 애가”(1960)는 전통악기(현오케스트라)를 위한 곡이지만, 비전통적인 연주기법과 음고, 리듬개념을 사용했고, 논란의 여지는 있겠으나 “음”으로 들리는 소리가 아예 없는 작품이다. 이들을 포함하여 많은 20세기 작품들이 컴퓨터음악 작곡가들을 위한 기반을 마련해주었다. 그럼에도 불구하고 이러한 작품들을 여전히 기악을 위한 (자동피아노나 현오케스트라), 표현기법과(피아노 롤, 그래픽 스코어), 연주형태(이들의 예에서는, 둘 다 상당히 전통적인)에 의한 것으로 해석할 뿐이다.

20세기 초반의 작곡가들이 “규칙을 깨고” 앞으로 나아갈 길을 탐구했다면, 지금 우리는 컴퓨터로 음악의 각 요소(파라미터)와 기존의 관례와 관행을 재정의할 기회가 있다. 음악의 창작과 배포의 민주화로 이러한 경향은 더욱 확장되는 중이다. 컴퓨터로 인해 소요 비용이 낮아졌기 때문에, 음악창작자는 더 이상 그들의 아이디어를 실현해 줄 오케스트라나 오페라단, 스튜디오의 권력 구조에 의존하지 않아도 된다. 인터넷이 청중에게 접근할 수 있는 새로운 방법을 열어주었다. 즉, 우리는 지금 오래도록 계속될 대탐험의 시대에 있다.

A “Moonshot Project” for Computer Music

My colleague Rowland Chen created an interesting challenge that I believe exemplifies the current problems in Computer Music research. (Chen/ Dannenberg/ Raj/ Singh 2020) Just as the goal of putting a man on the moon stimulated an array of technical advances in space exploration, with wide-ranging and important spin-offs, I believe a good “moonshot” project might stimulate and stretch Computer Music research.

Jerry Garcia was a founding member of the Grateful Dead. He is dead, but millions of fans miss him, and thousands of hours of live recordings survive. What if we could create a faithful imitation of Jerry Garcia? The problems we would have to solve span the range of Computer Music concerns, including:

- Sound: Model Garcia’s electric guitar sounds, including effects, amplifier distortion and sound propagation. Vocal sounds seem even more difficult.
- Control: Isolated guitar sounds are not enough. Perceived sound is influenced by articulation, bends, vibrato, frets and fingerings, all of which are time-varying, constrained by physics, the neuro-musculature system and mutual dependencies. Again, the singing voice is yet more difficult.
- Composition: The Grateful Dead are known for long improvisations and launching the “jam band” movement. One would expect a “Jerry Garcia” model to create new improvisations with long-term coherence, interaction and collaboration with human bandmates and faithful adherence to style. (Perhaps a continuing evolution of style is also necessary to keep fans interested and to justify new performances.)
- Collaboration: Part of the essence of the Grateful Dead is the collaboration among the band members in constructing extended “jams.” Musical coordination exists at all levels from beat- and measure-level synchronization to larger sections and transitions.
- In order to accomplish all this, it seems necessary to greatly extend the state-of-the-art in machine listening, especially source separation techniques. If we could isolate instruments in the 10,000 hours of Grateful Dead concert recordings that are available for study, we would at least have a wealth of interesting data. Even with that data, we need advances in the analysis of structure and style in those performances.

Whether we actually embark on a “moonshot” project, it is a good practice to set goals and to dream big. In my experience, real objective musical goals are invaluable in setting the research agenda.

컴퓨터 음악을 위한 "문쇼트" 프로젝트

나의 동료 로랜드 첸Rowland Chen은 컴퓨터 음악연구의 현 문제점을 짚는, 내가 믿기로 흥미로운 과제에 도전하였다. (Chen/ Dannenberg/ Raj/ Singh 2020) 사람이 달에 간다는 목표가 우주 탐험에의 기술적 진보를, 광범위하고 중대한 파생적 효과까지 낳으며 줄줄이 이루도록 한 것 같이, 괜찮은 "문쇼트" 프로젝트가 컴퓨터 음악 연구를 활발하게 하고 길게 지속시킬 수 있으리라 생각한다.

제리 가르시아Jerry Garcia는 그레이트풀 데드Grateful Dead[20세기 후반 미국의 상징적인 록밴드]의 창립맴버였다. 그는 죽었지만, 수백의 팬이 그를 그리워하고, 수천 시간의 음반이 남아있다. 제리 가르시아를 충실히 모방하는 프로그램을 만들 수 있다면 어떨까? 우리가 해결해야 할 문제는 다음 사항을 포함하여 컴퓨터 음악의 범주에 있다.

- 사운드: 가르시아를 모델로 하는 전자 기타 사운드, 이펙트와 증폭왜곡(앰프 디스토션), 소리전파(사운드 프로퍼게이션)를 포함한다. 보컬 사운드는 훨씬 더 어려워 보인다.
- 컨트롤: 순수한 기타 사운드로는 충분치 않다. 아티큘레이션, 벤딩, 비브라토, 프렛과 핑거링의 적용이 있어야 하고, 이들 모두 시간에 따라 유동적이며, 물리학과 신경-근육 시스템, 상호 의존성에 따른다. 다시 말하지만, 노래하는 목소리는 여전히 더 어렵다.
- 작곡: 그레이트풀 데드는 긴 즉흥연주와 "잼 밴드"라는 부분으로 시작하는 것으로 유명하다. "제리 가르시아" 모델이 장시간 일관되게, 상호작용하며 인간 밴드동료들과 충실히 스타일을 지키면서 새로운 즉흥연주를 해야 할 것이다. (아마도 스타일의 지속적인 진화도 팬들의 관심을 유지하고 새로운 공연을 정당화하는데 필요할 것이다.)
- 협업: 그레이트풀 데드의 핵심 중 하나가 "잼"을 구성하여 확장시켜 나갈 때 밴드맴버들 사이의 협동 작업이다. 음악에서의 협동은 한 박, 한 마디 단계로 일치시키는 것부터 보다 큰 섹션과 전환까지 모든 수준의 단계에서 존재한다.
- 이것들을 모두 달성하려면, 기계의 청취 능력을, 특히 음원을 분리하는 기술을 최고의 수준으로 크게 강화해야 할 것이다. 연구에 쓸 수 있는 1 만 시간의 그레이트풀 데드 콘서트 녹음자료에서 각 악기 소리를 분리해내기만 해도, 충분한 정도의 흥미로운 데이터를 갖게 되는 것이다. 그 데이터만 놓고 봐도, 그러한 공연 연주에서의 형식과 스타일을 분석하는 기술의 개발도 필요하다.

우리가 "문쇼트" 프로젝트에 실제로 착수하든 간에, 목표를 설정하고 큰 꿈을 꾸는 것은 좋은 행동이다. 내 경험상, 정말로 객관적인 음악적 목표는 연구 의제를 설정하는 데 매우 가치있다.

Conclusions

If we stand back far enough, we can see Computer Music as a grand undertaking to understand and automate *every* aspect of music making, with a clear progression:

- From primitive sound generation and reproduction, we have learned to create new sounds. Research continues to explore new sounds as well as to create better models for known acoustic sounds in all their richness and complexity.
- Beginning with simple event lists and other score-like representations, we have developed more complex and dynamic control approaches, leading to imitative computer-generated compositions and to interactive, responsive music systems.
- From early performances with fixed media, we have developed computer accompaniment systems, responsive robot musicians, and we have begun to study collaborative music making in greater generality.

I believe these trends help us to anticipate what the future will bring: Richer sounds and better synthesis models, better understanding for building higher-level musical forms from phrases to entire music compositions, and more sophisticated approaches to collaborative music making between humans and machines.

While these themes seem to be predictable, the exponential growth of computing power makes the details hard to even imagine, and we should expect *qualitative* changes on par with the shift from mainframes to laptops or books to Internet. These changes will continue to surprise us, but they will also open new and interesting avenues to pursue our goals.

Ultimately, our attraction to modeling, automation and computation in music is driven by the natural human urge to explore and learn. Let us hope that through this experience of constructing knowledge, we also learn to use it wisely for the benefit and enjoyment of society.

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I wish to thank the KEAMS organizers for the occasion to organize these thoughts. My work would not be possible without the support the School of Computer Science at Carnegie Mellon University and my many stellar colleagues and students, from whom I have learned so much. Throughout this paper, I have referenced particular papers I had in mind, but I also mention areas full of great contributions by many additional researchers. I believe a quick Internet search with obvious keywords will lead you to their papers, and I hope dozens of authors will forgive me for omitting references to their work here. I have certainly learned a lot from my Computer Music colleagues, whose friendship over the years continues to make this a great journey.

결론

한걸음 뒤로 물러나 충분히 생각해본다면, 컴퓨터 음악이란 음악을 만드는 데 '모든' 면모를 이해하고 자동화하는 웅대한 사업이며, 다음과 같은 명백한 진전이 있음을 알게 될 것이다.

- 초기의 사운드 생성과 재생 과정부터 새로운 소리를 만드는 방법을 학습해 왔다. 계속해서 새로운 소리를 탐구하고, 풍부함과 복잡함을 갖춘 기존의 음향 사운드를 보다 잘 따르는 모델을 구축하는 연구도 지속된다.
- 간단한 이벤트 목록이나 악보와 비슷한 다른 표현법을 시작으로, 더 복잡하고 역동적인 제어 방법을 개발하고 있으며, 컴퓨터로 생성하는 모방적 작곡과 상호작용적, 반응형의 음악 시스템으로 이어져오고 있다.
- 고정 매체를 사용한 초기의 공연 연주부터, 컴퓨터 동반연주 시스템, 반응하는 로봇 음악가를 개발하였으며, 더 큰 일반성을 갖는 협동 음악 창작에 대한 연구도 착수하였다.

이러한 동향을 살펴보는 것이 미래에 무엇을 얻게 될지 예견하는 데 도움이 될 것이라 믿는다: 더 풍부한 사운드와 더 나은 합성 모델, 악구부터 전체 작품까지 더 높은 수준의 음악형식 구성을 더 잘 이해하고, 인간과 기계가 협동하며 음악을 작곡하는 데 더 세심한 접근방법이 그것이다.

이러한 주제들이 예측가능한 것으로 보이겠지만, 컴퓨팅의 기하급수적 성장이 세세한 사항은 상상조차 어렵게 만들기 때문에, 메인프레임에서 노트북으로, 책에서 인터넷으로 전환된 것과 동등한 수준의 '질적'변화를 예상해야 한다. 이러한 변환은 항상 우리를 놀라게 하지만, 우리를 목표를 이뤄줄 새롭고 매력적인 길도 열어줄 것이다.

궁극적으로, 음악에서의 모델화와 자동화, 전산처리에 이끌림은 탐구하고 학습하고자 하는 자연적인 인간의 욕구에 의한 것이다. 이렇게 지식을 쌓는 경험을 하고 이를 사회의 이익과 즐거움을 위해 현명하게 활용하는 방법도 배우기를 희망한다.

감사의 말

이러한 생각을 정리할 기회를 준 한국전자음악협회 주최측에 감사를 전한다. 카네기멜론 대학 컴퓨터공학과와, 많은 것을 가르쳐준 나의 뛰어난 동료와 학생들의 지원 없이는 이 일이 불가능했을 것이다. 이 글 전체에 걸쳐, 내가 염두에 두었던 특정 논문들을 참고로 활용했을 뿐 아니라, 많은 다른 연구원들이 크게 기여한 분야들도 언급했다. 명확한 주제어와 빠른 인터넷 검색으로 그 논문들에 접근할 수 있으리라 믿으며, 참고목록에서 생략하게 된 수십 명의 저자들에게는 양해를 구한다. 나는 나의 컴퓨터음악 동료들에게서 많은 것을 배웠고, 그들과의 오랜 우정이 훌륭한 여정으로 계속되고 있음을 밝힌다.

References

Anderson, D. P./ Kuivila, R. (1990). A System for Computer Music Performance. *ACM Transactions on Computer Systems 8*(1): 56-82.

Bilbao, S. (2009). *Numerical Sound Synthesis: Finite Difference Schemes and Simulation in Musical Acoustics.* Wiley.

Block, G./ Chabot, X./ Dannenberg, R. (1989). Jimmy Durante Boulevard. On *Current Directions in Computer Music Research (CD-ROM)*. Cambridge, MA: MIT Press.

Chen, R./ Dannenberg, R./ Raj, B./ Singh, R. (2020). Artificial Creative Intelligence: Breaking the Imitation Barrier. *Proceedings of the 11th International Conference on Computational Creativity*: 319-325. Association for Computational Creativity.

Collinge, D. J. (1985). MOXIE: A Language for Computer Music Performance. *Proceedings of the International Computer Music Conference 1984*: 217-220. San Francisco: International Computer Music Association.

Dannenberg, R. (1985). An On-Line Algorithm for Real-Time Accompaniment. *Proceedings of the 1984 International Computer Music Conference*: 193-198. San Francisco: Computer Music Association.

Dannenberg, R. (1986). The CMU MIDI Toolkit. *Proceedings of the 1986 International Computer Music Conference*: 53-56. San Francisco: International Computer Music Association.

Dannenberg, R./ Derenyi, I. (1998). Combining Instrument and Performance Models for High-Quality Music Synthesis. *Journal of New Music Research 27*(3): 211-238.

Dannenberg, R./ Mercer, C. (1992). Real-Time Software Synthesis on Superscalar Architectures. *Proceedings of the 1992 International Computer Music Conference*: 174-177. International Computer Music Association.

Dannenberg, R./ Pellerin, H./ Derenyi, I. (1998). A Study of Trumpet Envelopes. *Proceedings of the International Computer Music Conference*: 57-61. San Francisco: International Computer Music Association.

Dannenberg, R./ Sanchez, M./ Joseph, A./ Capell, P./ Joseph, R./ Saul, R. (1990). A Computer-Based Multi-Media Tutor for Beginning Piano Students. *Interface - Journal of New Music Research 19*(2-3): 155-173.

Eigenfeldt, A. (2007). Real-time Composition or Computer Improvisation? A composer's search for intelligent tools in interactive computer music. *Proceedings of the Electronic Music Studies 2007.* www.ems-network.org/IMG/pdf_EigenfeldtEMS07.pdf.

Lewis, G. (2000). Too Many Notes: Computers, Complexity and Culture in "Voyager". *Leonardo Music Journal*: 33-39.

Mathews, M. (1969). *The Technology of Computer Music.* MIT Press.

Mathews, M. V. (1980). The Sequential Drum. *Computer Music Journal*: 45-59.

Mazzoni, D./ Dannenberg, R. (2002, Summer). A Fast Data Structure for Disk-Based Audio Recording. *Computer Music Journal 26*(2): 62-76.

Rowe, R. (1992). *Interactive Music Systems: Machine Listening and Composing.* Cambridge, MA: MIT Press.

Solis, J./ Chida, K./ Suefugi, K./ Taniguchi, K./ Hashimoto, S. M./ Takanishi, A. (2006) The Waseda Flutist Robot WF-4RII in Comparison with a Professional Flutist. *Computer Music Journal 40*(4): 12-24.

Vercoe, B. (1985). The Synthetic Performer in the Context of Live Performance. *Proceedings of the 1984 Interntional Computer Music Conference*: 199-200. International Computer Music Association.

Wessel, D./ Lavoie, P./ Boynton, L./ Orlarey, Y. (1987). MIDI-LISP: A LISP-Based Programming Environment for MIDI on the Macintosh. *Audio Engineering Society Conference: 5th International Conference: Music and Digital Technology.* AES.

Winkler, T. (1998). *Composing Interactive Music: Techniques and Ideas Using Max.* Cambridge, MA: MIT Press.

Xia, G./ Kawai, M./ Matsuki, K./ Fu, M./ Cosentino, S./ Trovato, G./ . . . Takanishi, A. (2016). Expressive Humanoid Robot for Automatic Accompaniment. *SMC 2016 - 13th Sound and Music Computing Conference, Proceedings*: 506-511.

Xia, G./ Wang, Y./ Dannenberg, R./ Gordon, G. (2015). Spectral Learning for Expressive Interactive Ensemble Performance. *Proceedings of the 16th International Society for Music Information Retrieval Conference*: 816-822.

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Musical Motion at Different Scales:
Creative Analysis and Resynthesis of Musical Contour Spectra

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In the context of music technology, Fourier analysis is generally applied directly to sampled sound waves, with the goal of revealing timbral information about the sound or sounds in question. By contrast, this paper presents a software tool ("Spectral Musical Contour Explorer") for applying Fourier analysis to more abstract musical time series; for instance, one can analyze a melody as a time series of pitches, or a recording as a time series of RMS volume measurements. Such analyses can uncover salient and musically meaningful periodicities within the structure of musical works. Moreover, the different time scales of these periodicities reflect the multilevel nature of musical structure (e.g. meter, phrase, form). Finally, the software can be used creatively to resynthesize new pitch and volume contours from a hand-selected portion of the analysed spectrum. In particular, we discuss several compositions by the author that use this process to generate novel musical material from melodic and dynamic contours found in canonical repertoire.

Keywords: Fourier Analysis, Resynthesis, Contour, Composition, Software, Form, Melody.

The mathematical tool of Fourier Analysis is used in a wide range of fields and contexts, and can be applied both to time-series data, or to data distributed over another (e.g. spatial) dimension. In music and audio analysis, the most typical use of Fourier Analysis is the application of a Discrete Fourier Transform (DFT)—most typically a Fast Fourier Transform (FFT)—to a sequence of audio samples. This is a powerful tool for timbral analysis, filtering, synthesis, efficient convolution reverb, and many other musical applications (Smith 2007).

Aside from forming the basis of many of the software tools that musicians use today, this application of Fourier Analysis played a central role in aesthetic movements within the field of music composition, in particular the advent of so-called *spectralist* approaches in the 1970's (Moscovich 1997). Within the field of music theory, there has recently been a resurgence of interest in a different usage of Fourier Analysis, namely its application to abstract musical structures, such as pitch-class distributions (Amiot 2017; Quinn 2007). Here, rather than samples evenly spaced in time, the analysis focuses on samples within circular pitch-class space, an 'outside-time' musical structure, to use the language of composer Iannis Xenakis (1992).

This paper considers a third category of usage: the application of Fourier Analysis to 'in-time' structures that represent changes in abstract musical parameters, such as pitch and volume. (These fluctuations will be termed 'musical contours' throughout this paper.) Such an approach has been considered sporadically, for example by Nettheim (1992) and Voss (1978), and a similar analysis and resynthesis approach using wavelet analysis has been taken by Kussmaul (1991), but it has yet to receive widespread recognition.

This paper both revives this line of research and presents a newly developed piece of software—entitled "Spectral Musical Contour Explorer"—for creatively analyzing and resynthesizing novel melodies and dynamic contours using this approach. Finally, the creative results of this exploration are discussed, in the form of several of my own compositions.

Non-technical Introduction to Fourier Analysis

For the sake of readers coming from a more musical than mathematical background, we begin with a non-technical introduction to the tool of Fourier Analysis, as applied to a recorded waveform. Fourier Analysis is what we use when we talk about the spectrum of a complex sound; for instance, when we say that a clarinet tone has only odd harmonics, or that the first harmonic of a trumpet is stronger than its fundamental, we are referring to the results of Fourier analysis. The central idea is that a complicated motion—in this case, the motion of an air particle under the influence of a trumpet or clarinet—can be decomposed into a superimposition of very simple motions at different speeds.

Figure 1a shows the waveform (i.e. graph of the fluctuation in air pressure) of several periods of a trumpet tone. The unique shape of the waveform creates the trumpet's sonic signature. Note that these fluctuations happen very quickly; the shape repeats three times over the course of 5ms, which translates to 600 oscillations per second (Hz), or roughly a concert D5.

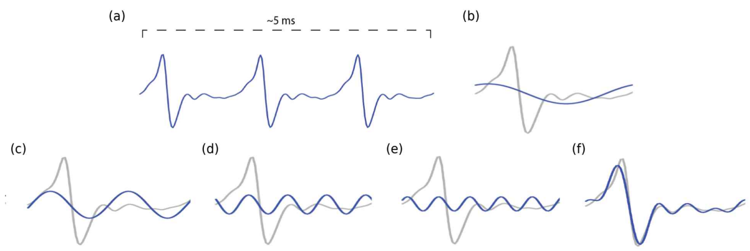

Figure 1. (a) Short excerpt from a trumpet waveform showing a repeated fluctuation in air pressure. (b)-(e) One period of that fluctuation (light gray), with the 1st (fundamental), 2nd, 4th, and 5th harmonics isolated, respectively (blue). (f) The recombination of those harmonics (blue) as compared with the original waveform (light gray).

What Fourier synthesis does is break down this complex signature into a sum of sine waves at integer multiples of the 600Hz frequency of the complex pattern. Thus, for a 600Hz trumpet tone, we have components at 600Hz, 1200Hz, 1800Hz, 2400Hz, etc., which we would term the 1st, 2nd, 3rd, and 4th *harmonics* or *partials*. Each partial has its own weighting (*amplitude*) and alignment (*phase*).

We can see what this looks like in Figures 1b-e, which show the 1st, 2nd, 4th, and 5th partials of the trumpet waveform respectively (the original waveform is shown in gray for reference). The first partial completes one cycle for every cycle of the complex trumpet tone; thus it, like the trumpet tone, is oscillating at 600Hz. The second partial completes two cycles for every cycle of the trumpet tone; thus it is oscillating at 1200Hz. Of the four partials shown, notice that the second partial is the strongest, and that the phase of each of the sine waves is such that its peaks and valleys align well with the peaks and valleys of the complex waveform.

Figure 1f shows the sum of these sine waves, which very nearly reproduces the original trumpet waveform. In fact, there is no physical or acoustical difference between the simultaneous sounding of the sine waves in 1b-e and the sound of their sum in 1f. If we wished to reproduce the original trumpet wave with perfect fidelity, we would simply need to include the remaining relatively weak higher harmonics.

It turns out that there is only one way to break a complex wave shape into a sum of sine waves like this, and we call this unique combination of harmonics with different amplitudes and phases a *spectrum*. Thus, when we say that the sound of a trumpet has a strong second harmonic, we mean that the effect of the complex pressure wave produced by a trumpet is identical to the effect of a very specific combination of sine waves added together, and that the second of these sine waves is the strongest.

Musical Countour Spectra

In a musical context, the term *spectrum* is very readily associated with *timbre* and with the direct application of Fourier Analysis to a recorded waveform. Indeed, many canonical examples of the "Spectral" music that emerged in the 1970's (e.g. Gerard Grisey's Les Espaces Acoustiques) are based specifically on transcribing the results of such an analysis to music notation (Féron 2011).

However, because Fourier analysis is an abstract mathematical tool, it can be just as easily used to analyze the variation in any other musical parameter, at any time scale. For instance, the pitch of a melody can be seen as a time-varying property, operating on the scale of seconds rather than milliseconds. Such analysis, combined with creative resynthesis, can be a source of novel musical material, as we shall see.

Figure 2 depicts the melody of "Pop Goes the Weasel," first in traditional music notation, and then as a time-varying pitch contour. By depicting the pitch of the melody in this way, we see that it is, mathematically, just like the trumpet waveform from before[1]. The only difference is that this wave represents the motion of an abstract musical parameter, rather than of air pressure directly, and that the variation is on the scale of seconds rather than milliseconds.

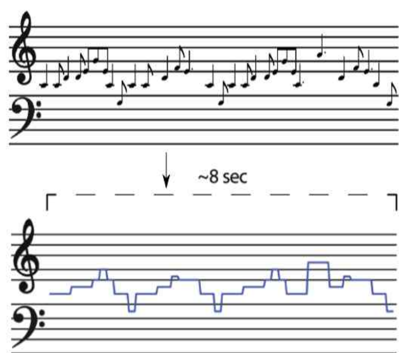

Figure 2. The melody "Pop Goes the Weasel," first in traditional music notation, and then reinterpreted as a time-varying pitch contour.

There is, therefore, no reason we cannot apply Fourier analysis to this pitch contour, just like we did with the trumpet waveform. As with the trumpet, these oscillations operate at 1x, 2x, 3x, etc. the frequency of the melody itself[2], and each of these 'partials' has its own amplitude and phase, with some partials being especially influential.

Figure 3 shows some of the lower partials. The first partial (Figure 3a) is not particularly strong, but its phase is nevertheless aligned so that the peak coincides with the highest note (A4) of the melody. The same can be said of the second partial (Figure 3b). The strongest component is the fourth partial, which completes four full cycles over the course of the melody (Figure 3c). Why is this?

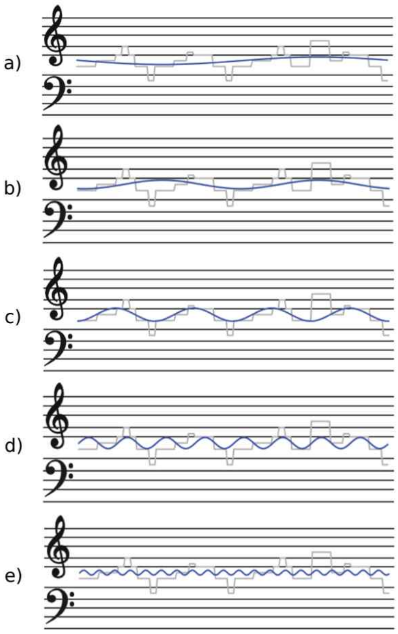

Figure 3. The (a) 1st/Fundamental, (b) 2nd, (c) 4th, (d) 8th, and (e) 20th harmonics of harmonics of the pitch contour of the melody "Pop Goes the Weasel" (blue), superimposed on the original contour (light gray).

The reason is that the melody itself is in four parts, and each of its first three phrases follows the same pattern of low then high. The final phrase, starting on the A, the highest note in the melody, is somewhat of an exception. In order to compensate, the first and second partials are aligned so as to peak at this exact moment, as is the eighth partial shown in Figure 3d. The eighth partial also helps to create the more local peaks at G4 in the first and third phrases.

Adding together the partials depicted in Figure 3a-d, we arrive at the contour shown in Figure 4a, which tracks the motion of the melody fairly faithfully, albeit a little too smoothly. In order to achieve the flat pitch plateaus that our western ears have come to expect, we need to include more rapid fluctuations like the 20th partial (Figure 3e) to help flatten out the peaks of the slower sine waves (Figure 4b). As with the trumpet waveform, by including enough partials we can reproduce the original melodic contour with perfect fidelity.

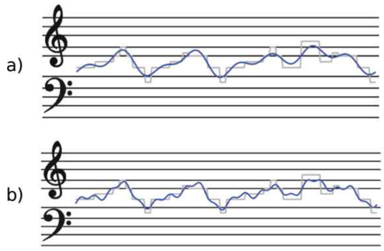

Figure 4. (a) The sum of partials 1, 2, 4, and 8, producing a passable approximation of the melodic contour. (b) Sum of partials 1, 2, 4, 8, and 20, showing that partial 20 helps to flatten out some of the peaks into plateaus.

A Mathematical Schenkerian Analysis

The above should give some indication of the potential for using this kind of Fourier Analysis as an analytical tool. Among the magnitudes and phases of the various partials was valueable information about the structure of the melody, from its overall shape (1st and 2nd partials), to its phrases (4th partial), to hints of its motivic and rhythmic structure (8th partial). Those familiar with the theories of Heinrich Schenker may note a certain kinship here, in that both Schenkerian analysis and this application of Fourier Analysis represent a hierarchical view of musical structure. (In Schenkerian analysis, this hierarchy is represented by a range of interrelated structural levels, from background (*Ursatz*), to middleground, to foreground (Cadwallader/ Gagné 2007).)

From an analytical point of view, the process described above may provide a valuable complement to the process of Schenkerian Analysis, with the former valued for its objectivity, and the latter for its subjectivity.

A Tool for Creative Resynthesis

The illustrations in Figures 2-4 were produced using a tool that I created for analysis and resynthesis of musical contour spectra, called "Spectral Musical Contour Explorer." This program was created in Python, using PyQt5 as the underlying GUI framework, and using an embedded ChucK (Wang/ Cook 2004) binary for rudimentary sound synthesis. A more complete screenshot of the program is shown in Figure 5.

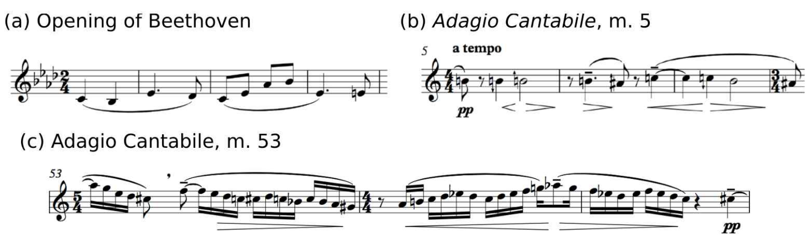

Figure 5. Comparison of (a) the opening melody from the second movement of Beethoven's Pathétique and (b) a corresponding passage in Adagio Cantabile. (c) is an excerpt from towards the end of the work

To begin with, the user is allowed to load either a MIDI file or a WAV file. In the case of a MIDI file, the average pitch of all active MIDI notes over time is plotted against a grand staff[3], while in the case of a WAV file, a plot of the variation in RMS volume over time is displayed. When inputting a MIDI file, the user is prompted for a length, in quarter notes, to assign to each sample; when inputting a WAV file, the user is prompted for the desired window size for calculating the RMS.

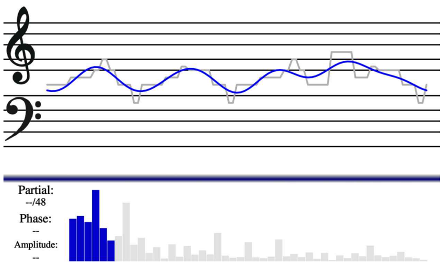

Figure 6. Screenshot from "Spectral Musical Contour Explorer." The bottom half of the screen shows the contour spectrum of the melody, with active partials in blue and inactive partials in gray. The top part of the screen plots both the original melody (in gray) and the reconstructed melody (in blue).

By mousing over the partials of the spectrum in the bottom half of the screen, additional information about phase and amplitude can be viewed, and the user can then click any these partials to toggle them on and on or off. In this way, any partial spectral reconstruction of the contour can be achieved. Finally, the samples of the reconstructed contour can be exported in the form of a text file, so that they can be used in a composition, or for further analysis.

Creative Results

Adagio Cantabile

The first piece in which I made use of this technique was *Adagio Cantabile*, for oboe and guitar. Using as source material the main theme of the second movement of Beethoven's *Sonata Pathetique, Op. 13*, I performed Fourier analysis and resynthesis on both pitch and rhythm independently (encoding rhythm as a sequence of note length samples[4]). A happy accident occurred in this process: since I was treating pitch values as continuous, rather than discrete, I ended up with microtonal inflections in the resulting resynthesis. This ended up becoming a central aspect of the oboe part.

After exploring the space of possible reconstructions, both in pitch contour and rhythm, I ended up with a collection of short melodic snippets, which I ultimately assembled using pencil and paper. Figure 6 compares the opening melody of the Beethoven (a) with a two excerpts from *Adagio Cantabile* featuring a partial reconstruction of the melody. In (b), the overall contour of the melody has been removed, leaving only the slight microtonal deviations. In (c), taken from near the end of the work, it is the local ornamentation—the higher frequency information—that has been removed, leaving a melodic line that sweeps gradually up and down. In this latter case, I allowed myself considerable flexibility in choice of accidentals, letting my ear guide such decisions intuitively.

Unraveled

The second piece in which I used this technique was *Unraveled,* for Percussion Quartet and Impossible Electronic Orchestra. The title gives a hint as to the source material: the famous melody from Ravel's Bolero. I used the software described here to analyse and resynthesize the melody in various degrees of recognisability, and then had these reconstructions performed by an "Impossible Orchestra," consisting of pitch-bent samples of orchestral instruments.

As with *Adagio Cantabile*, then, the contour in question is a melodic pitch contour. An added wrinkle in this case, however, is that rolls in percussion parts are used to emphasize the individual partials of the melodic contour, with many of these rolls superimposed on one another at a given time. Thus, though the fission process of Fourier analysis, the monophonic melody gives rise to a heterophonic accompaniment, one which emphasizes details within the melody itself.

Anamnesis

The third (and most recent) work that I composed using spectral analysis and resynthesis of musical contours is *Anamnesis* for Chamber Orchestra. Anamnesis differs from *Adagio Cantabile* and *Unraveled* in that the musical contour being analysed was a dynamic contour, rather than a pitch contour. Here, again, I used a famous work as the source material for analysis: the *Allegretto* from Beethoven's *Symphony No. 7.*

Figure 7a shows a screenshot (from the program *Audacity*) of the recording by Carlos Kleiber and the Vienna Philharmonic Orchestra. Figure 7b shows this same recording, as loaded into "Spectral Musical Contour Explorer": a dynamic contour has been created by calculating RMS values for every half-second of audio, effectively resulting in a unipolar version of what we see in Audacity. Figures 7c, d, and e show three examples of strong periodicities found in the dynamic contour through analysis. Notice, for instance, how the second harmonic depicted in Figure 7c highlights the two main peaks of intensity within the movement.

I then used the *SCAMP* libraries for computer-assisted composition in Python (Evanstein 2018) to orchestrate these different layers of motion, with some instruments playing the larger swells, others playing the mid-level swells, and still others playing the fastest-moving swells. Thus, as in *Unraveled*, Fourier Analysis broke a single contour (this time a dynamic contour) into a heterophonic texture of simple gestures. Figure 8 shows an excerpt of the texture in the violins from the opening of the work, consisting of many short, overlapping swells. Below, one can see a larger swell beginning, tremolando, in the cello section.

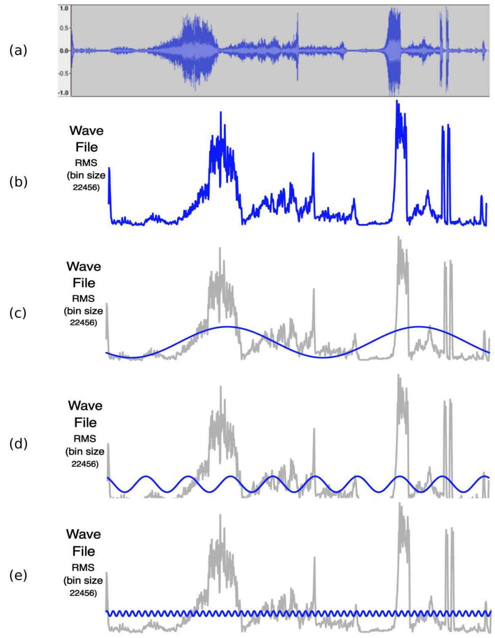

Figure 7. Analysis of the dynamic contour of the *Allegretto* from Beethoven's *Symphony No. 7*. (a) The dynamic shape of the movement as shown in Audacity. (b) The same contour, as represented in "Spectral Musical Contour Explorer." (c), (d), and (e) Three prominent periodicities found at different time scales.

It should be noted that, as in *Adagio Cantabile* and *Unraveled*, the process of musical contour analysis and resynthesis was merely the starting point for the composition. The final work also resulted from numerous other musical processes and decisions, which were largely intuitive in nature.

Conclusions

There are several possible avenues of further research and compositional practice. From the point of view of composition, each new contour represents a different initial condition for the creative process, as does each possible approach to resynthesis (e.g. removing all but the low partials, the odd partials, the prominent partials, etc.). As the above examples illustrate, this approach can generate snatches of musical material (as in *Adagio Cantabile*) and/or it can form the basis of the work's overall form (as in *Anamnesis*).

Possibilities can be further expanded by the development of the tool itself. For example, one could incorporate contours based on other musical parameters: instead of RMS volume, an inputted sound file could be analyzed in terms of its variation in spectral centroid, spread, flux or kurtosis, or on its zero-crossing rate. One could also allow contours to be broken up into windowed segments, which would be valuable with longer inputs.

Another interesting possibility would be to allow for modification of the phase of partials before resynthesis of the contour. Although phase changes have little audible effect for sound waves in the range of human hearing, the effect may be substantial at the time scale of the musical contours discussed here. In many cases, the effect of phase is as important as, if not more important than, magnitude in establishing structural boundaries within a data set (Bartolini et al. 2005).

In short, I envision this approach, and the tool I have developed, as one among many that could serve as a source of inspiration for composers in their creative process.

Figure 8. String excerpt from the opening of Anamnesis.

References

Amiot, E. (2017). A Survey of Applications of the Discrete Fourier Transform in Music Theory. In Pareyon, G./ Pina-Romero, S./ Agustín-Aquino, O. A./ Lluis-Puebla, E. [Eds.]. *The Musical-Mathematical Mind: Patterns and Transformations*: 17–28. Springer International Publishing. https://doi.org/ 10.1007/978-3-319-47337-6_3

Bartolini, I./ Ciaccia, P./ Patella, M. (2005). WARP: Accurate retrieval of shapes using phase of Fourier descriptors and time warping distance. In *IEEE Transactions on Pattern Analysis and Machine Intelligence* 27/1: 142–147. https://doi.org/10.1109/TPAMI.2005 .21

Cadwallader, A. C./ Gagné, D. (2007). *Analysis of Tonal Music: A Schenkerian Approach*. Oxford University Press.

Evanstein, M. (2018). *SCAMP: a Suite for Computer-Assisted Music in Python*. GitHub. https://github.com/ MarcTheSpark/scamp

Féron, F.-X. (2011). The Emergence of Spectra in Gérard Grisey's Compositional Process: From Dérives (1973–74) to Les espaces acoustiques (1974–85*).* In *Contemporary Music Review* 30/5: 343–375. https://doi.org/ 10.1080/07494467.2011.665582

Kussmaul, C. (1991). Applications of the Wavelet Transform at the Level of Pitch Contour. In *Proceedings of the International Computer Music Conference*: 483–483.

Malt, M./ Schilingi, J. (1995). Profile libreria per il controllo del profilo melodico. In *Colloquio diInformatica Musicale (XI CIM)*: 237–238.

Moscovich, V. (1997). French Spectral Music: An Introduction. In *Tempo* 200: 21–28. https://doi.org/10.1017/ S0040298200048403

Nettheim, N. (1992). On the spectral analysis of melody. In *Interfac*e 21/2: 135–148. https://doi.org/10.1080/ 09298219208570604

Quinn, I. (2007). General Equal-Tempered Harmony: Parts 2 and 3. In *Perspectives of New Music* 45/1: 4–63. JSTOR.

Voss, R. F. (1978). ''1/f noise'' in music: Music from 1/f noise. In *The Journal of the Acoustical Society of America* 63/1: 258. https://doi.org/10.1121/1.381721

Smith, J. O. (2007). *Mathematics of the Discrete Fourier Transform (DFT): With Audio Applications.* Julius Smith.

Wang, G./ Cook, P. (2004). ChucK: A programming language for on-the-fly, real-time audio synthesis and multimedia. In *Proceedings of the 12th Annual ACM International Conference on Multimedia*: 812–815. https://doi.org/ 10.1145/1027527. 1027716

Xenakis, I. (1992). *Formalized Music: Thought and Mathematics in Composition*. Pendragon Press.

[1] This approach of treating a melody as a time-varying pitch function was taken by Malt and Baboni-Schilingi in their work on the *Profile* library for *OpenMusic* (Malt/ Schilingi 1995).

[2] For those more familiar with Fourier analysis, it will be apparent that I am using a window size equal to the whole length of the melody. There is, therefore, an underlying assumption that the melody itself is cyclic. This may be more or less appropriate in different situations.

[3] In the *Pop Goes The Weasel* examples above, the inputted MIDI file was monophonic.

[4] The results turned out to be quite interesting with rhythm: When no frequencies (except DC) of oscillation were present, the rhythm was static, with all notes the same length. When lower partials were included, the rhythm started to accelerate and decelerate at the faster and slower parts of the melody. As I included faster and faster oscillations, these accelerandi and decelerandi became more and more local, until all of the detail of the original rhythm was recreated.

[Abstract in Korean | 국문 요약]
다른 규모에서의 음악적 모션: 음악적 윤곽선 스펙트럼의 창조적인 분석과 재합성

마크 에반스타인

뮤직 테크놀로지의 문맥에서, 푸리에 분석은 소리의 음색 정보나 문제가 되는 사운드를 밝힐 목적으로, 일반적으로 샘플화된 소리 파동에 직접적으로 적용된다. 대조적으로, 이 글에서는 푸리에 분석을 보다 추상적인 일련의 음악적 시간에 적용하기 위해 "음악적 윤곽선 스펙트럼 탐험자Spectral Musical Contour Explorer"라는 소프트웨어 도구를 제시한다; 예를 들면, 선율을 시간에 따른 음고 시리즈로, 녹음정보를 시간에 따른 실효RMS 볼륨 측정값의 시리즈로 분석할 수 있을 것이다. 이러한 분석법은 음악작품의 구조 내 현저하게 나타나는, 음악적으로 의미있는 규칙성을 밝혀준다. 더욱이, 서로 다른 시간 척도에서의 주기성은 음악의 구조(예를 들어, 박자, 악구 형식)에서 다차원적인 속성을 반영한다. 마지막으로, 소프트웨어로 분석된 스펙트럼 일부분을 직접 선택한 것에서 새로운 음고와 볼륨 윤곽선을 창의적으로 재합성할 수 있다. 특히, 고전적인 레퍼토리에서 발견되는 선율적, 다이내믹적 윤곽선으로부터 새로운 음악적 재료를 도출해내기 위해 이러한 과정을 활용한 저자의 몇몇 작품들을 논한다.

주제어: 푸리에 분석, 재합성, 윤곽선, 작곡, 소프트웨어, 형식, 선율.

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Listening to Emojis through Sonification

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This article briefly presents the artistic research – an experimental audiovisual project by the author on the theme of data translation by employing Emojis as an input-image for data sonification. Definitions; the background of the study; and the use of sonification techniques: audification, parameter Mapping, Auditory Icons, and Earcon in the project are accounted for in the artistic purpose. The brief also includes a discussion of the visual designs, selected emojis inputs, sound generation methods, and the design of the user controls.

Keywords: Experimental Music, Audiovisual, Emoji, Sonification

Sonification background and related works

Composers are artists focused on musical composition or the art of organizing sounds. Composers compose a piece of work through interpretation and the transformation of ideas in the abstract form and moving from imagination and inspiration into a piece of music. This process of transformation from abstract-materials into musical compositions is also relevant to sonification, a process concerned with a process of converting abstract materials into the physically audible domain.

The earliest definition of sonification was given by composer and researcher Greg Kramer: "representing data with non-speech sound" (Kramer 1994), and "sonification is the use of non-speech audio to convey information" (Kramer et al 2010). Later, several researchers developed and extended the definition as "the technique of rendering sound in response to data and interactions" (Hermann et al 2011), and a recent definition which considers the artist's intention: "Sonification is any technique that translates data into non-speech sound with a systematic, describable, and reproducible method, to reveal or facilitate communication, interpretation, or discovery of meaning that is latent in the data, having a practical, artistic, or scientific purpose" (Liew/ Lindborg 2019).

Sonification is widely used for interdisciplinary purposes, contrasting the early uses that were mostly employed for scientific use. The "Geiger counter", is one of the most commonly employed methods of sonification. This tool is used to detect radiation by sonifying the intensity of radiation values into audible sounds. (Dombois/ Eckel 2011: 304) Another example is the "stethoscope", a medical tool for diagnosing heart or breathing issues (ibid.). This simple method of sonification is still in use for medical purposes today.

In the artistic domain, several artists have exploited sonification in their artistic practices such as Andrea Polli, who employed climate change data as a sonification source. Her goal is to create artwork that raises awareness of global warming (Polli 2016). Marty Quinn also utilizes scientific data for artistic purposes. One of the distinctive works is The Climax Symphony (Quinn 2001). Christina Kubisch is another artist who explores and sonifies electrical fields (such as street walking, electric devices, etc.) These sonic fields exist everywhere but cannot be heard without sonification. Kubisch's artwork lets participants explore several sites and the results of the magnetic field sonification are delivered to participants by her custom headphones (Dombois / Eckel 2011: 319; see also Kubisch 2016). Moreover, there are hundreds of artists actively employing data sonification in their artwork which are not mentioned here; however, within this same theme of creative and artistic research, the author has been working on several related audiovisual projects: 1(X)MB (Janbuala 2019) and F(r)ee Road (Janbuala 2019) that embraces sonification as an artistic process.

In the "Listening to Emojis" project, four methods of sonification are employed: *audification*, which directly renders the input source into the audible range; *parameter mapping*, which maps the input source into musical properties; *earcon*, a method that interprets and designs a short musical motive from the sonification sources and; *auditory icons*, a method that interprets the metaphoric relations of sounds and their sonified objects. Further explanation will be found in the sections below.

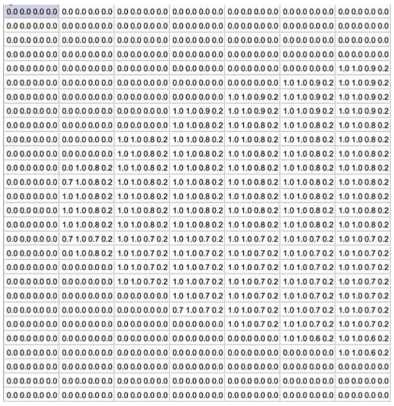
Listening to the emojis project

The project aims to create the artwork from image sonification and to make an interactive experimental-audiovisual piece in which all processes are prepared for one computer and one performer. The piece is titled "48 Emotions" (Janbuala 2020).

Selecting Emojis

The project employed emojis which represented our feeling instead of linguistic expression. The use of Emojis has grown rapidly in modern times mostly in part to its integration into smartphones and social media platforms. The Listening to Emojis project features forty-eight selected emojis to function as input for the sonification process. Each of the selected emoji visually represents different emotions. The emojis featured here are encoded in the ".png" file format, and each is scaled to three different resolutions: 28 x 28 pixels, 144 x 144 pixels, and 300 x 300 pixels. Each resolution has a unique effect on the sound rendering process. In each pixel's location contains color data ARGB (as the order of Jitter). The range of RGB color data is between 0 – 255. This data is scaled to the integers in the range of 0 – 1 for use in sound generative purposes.

Figure 1. Sample of selected emoji "Smiling face with open mouth" in 28 x 28 pixels.



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0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	0.0 0.0 0.0 0.0	1.0 1.0 0.9 0.2
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Figure 2. Color data (ARGB) inside the smiling face with open mouth emoji.

Sound generative process

Two kinds of data are used for sound generation through the employed sonification techniques: still-images and moving images (video). What made moving images data different from still images? The output data of a still image is static tonal information. In contrast, moving images create streams of data that are used to render the time domain and dictate the duration of each sound. The sound generative process is executed through sonification techniques programmed by the author in the Max graphical coding environment (Cycling'74). The custom patch works by extracting the color data (ARGB as the order of jitter) from the data stream of the video input. The sonification input source is unique color data from each of the moving images which factor details such as the placement and composition of objects and obstacles within each emoji. Four different methods are implemented to add dimensions to the sonic outcome. Firstly, *audification*, the process of scaling streaming data directly into the audible spectrum, results in a generative process that comprises a majority of the pieces' sonic outcome. Because the visual elements vary from one emoji to the next this technique directly transforms color data of emojis into a sampling of sound waves before rendering into the sound (see Dombois/ Eckel 2011: 301). The results of *audification* provide a pallet of sounds resembling that of noise but are very reactive to the visual elements and provide sounds with a vivid resemblance of the visual input. Secondly, the process of *parameter mapping* is used for composing the streaming data into musical properties (Grond/ Berger 2011) through association. This project employs *parameter mapping* of the streaming data as means of creating an *ostinato* motif (a continually repeated rhythmic pattern). Instead of rendering all streaming video data, this process measures the data stream at only specific intervals (snapshots) which results in static images and rigid data sets. The results data is rendered into an ostinato motif using four Triangular-wave generators. This tonal addition provides a tonal or melodic element unique to each emotion and plays a role in associating symbolism in each icon to a music motif. The third process is known as *earcon*. In this process, the author composed forty-eight short motifs through an artistic interpretation of the emojis. This method provides a different approach to the composition because it does not rely on the color's data stream, but, rather that of our human interpretation. The resulting designs are made audible by four Sine-wave oscillators (see McGookin/ Brewster 2011) in the Max environment. The *auditory icon*s method of sonification is the fourth and final method. This process of sonic interpretation analyzes the metaphoric relationship of each emoji (see Brazil/ Fernström 2011). In this project, emojis are interpreted by assigning to each a short sequence of metaphorical sounds. Here the author employed speech synthesis by way of Text to Speech voice "Kanya" from Apple Computer macOS Operating System as a source for sound generation. The result is forty-eight sonic characters (see the appendix). Further explanations of these sonification techniques can be found in the sonification handbook (Hermann et al 2011).

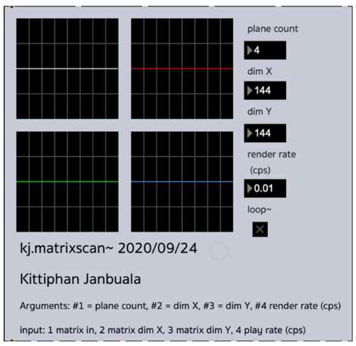

Figure 3. Custom sonification patch by the author: the purpose of the patch is to extract color data for parameter mapping sonification and audification.

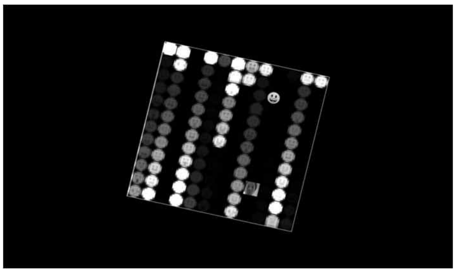

Figure 4. Example of the artwork.

Live interactive design

The artwork's intention is to include elements of live control by way of a performer. The role of the performer is to control the user-object, firstly, to avoid the obstacles (animate emojis) which be affected sound generation when object collision, and secondly, to reach the target emoji for the process to the next emoji's events. The control user-object was designed for simple use and utilizes computer keys (AWSD). Performers are able to animate the control-object in four directions: A for moving left, D for moving right, W for moving upward, and, S for moving downward. A webcam is also employed for interactive purposes. The webcam allows the performer's face to become the control-object. The dataset derived from the webcam's video stream allows every move and facial gesture to contribute to the visualization and sonification processes.

Figure 5. The control object keys.

Conclusion and further development

The use of sonification in artistic practices unfolds new creative possibilities for composers and sound artists. Many of the mentioned artists (and many which the author did not account for in this paper) are paving the way to a new sound organization, musical expression, and bring the music/ sound art scene into an exciting aspect. Although sonification is widely used in the scientific fields, it is beginning to play a significant role in providing artists with new opportunities in the creative domain.

This artistic research project is in its early phase of aesthetic development as an experimental audiovisual composition. The selected forty-eight Emojis have been methodically explored to create forty-eight unique and generative data sets. These data sets represent the images at the input of each process. The generative speed and complexity of these data sets provide new possibilities in the creative pursuits of sonification. The color properties (ARGB), symbolic resemblance, and geometric properties of these images are employed as composition source materials. In addition, there are performative parameters that arise in the programming process. These parameters provide an opportunity for the composer's intention such as the rendering rate, or mapping parameters such as position and zoom to function as musical properties. However, there are several points to improve for future development such as the sound's timbre, which seems restricted by the direct sonification processes; the sonic diversity, increasing the differences in data sets; and the dynamics, where more controls may provide more musical or performative outcomes, systematic adaptations and continual development of the sonification plan will allow for a greater variety of sounds and impressions.

References

Brazil, Eoin/ Fernström, Mikael (2011). Auditory icons. The sonification handbook. Logos Verlag Berlin: 325.

Dombois, Florian/ Eckel, Gerhard (2011). Audification. The sonification handbook. Logos Verlag Berlin 317: 304, 319.

Grond, Florian/ Jonathan Berger. (2011). Parameter Mapping Sonification. The sonification handbook. Logos Verlag Berlin: 363.

Hermann, Thomas/ Hunt, Andy/ Neuhodd, John G. (2011). Introduction. The sonification handbook. Logos Verlag Berlin: 1.

Janbuala, Kittiphan. (2019). 1(X)MB. https://youtu.be /2Zg5wEGmJm0. Accessed September 28, 2020.

Janbuala, Kittiphan. (2019). F(r)ee Road. https://youtu.be/ oF6aX5GnMd0. Accessed September 27, 2020.

Janbuala, Kittiphan. (2020). 48 Emotions. https://youtu.be/ duRK3hguawM. Accessed September 28, 2020.

Kramer, Gregory. (1994). "An introduction to auditory display." Auditory display-Sonification, audification and auditory interfaces: 1-77.

Kramer, Gregory/ Walker, Bruce/ Bonebright, Terri/ Cook, Perry/ Flowers, John H./ Miner, Nadine/ Neuhoff, John. (2010). Auditory display: sonification, audification and auditory interfaces, Addison-Wesley Longman Publishing Co., Inc.

Kubisch, Christina. (2016). Electrical Walks. http://www.cabinetmagazine.org/issues/21/kubisch.php. Accessed September 27, 2020.

Liew, Kongmeng / Lindborg, PerMagnus. (2020). A Sonification of Cross-Cultural Differences in HappinessRelated Tweets." *Journal of the Audio Engineering* Society 68, no. 1/2: 25-33.

McGookin, David/ Stephen Brewster. (2011). Earcon. The sonification handbook: 339.

Polli, A. (2016). "Sonifications of global environmental data." Environmental sound artists: in their own words: 2-7.

Quinn, M. (2001). Research set to music: The climate symphony and other sonifications of ice core, radar, DNA, seismic and solar wind data, Georgia Institute of Technology.

Appendix: Earcon designs, and Auditory Icons design

Sequence	Descriptions	Melodic Event	Kenya's speech
1	smiling face with open mouth		Ha
2	smiling face with open mouth and smiling eyes		Aha
3	grinning face with smiling eyes		Hee hee hee
4	smiling face with open mouth and cold sweat		Ha ha(down tone)
5	face with tears of joy		Ha huee huee huee
6	slightly smiling face		Nguem
7	smiling face with heart shaped eyes		Wow woo woo woo woo
8	face throwing a kiss		Chup phew
9	kissing face		Chup
10	kissing face with closed eyes		Chuuuup
11	kissing face with smiling eyes		Um chup
12	face savouring delicious food		Paeb peab
13	face with stuck out tongue		Baaae
14	face with stuck out tongue and tightly closed eyes		Hee baae
15	hugging face		Um hm
16	smiling face with smiling eyes and hand covering mouth		HU hu hu
17	face with finger covering closed lips		Shu shu
18	thinking face		Ummmm
19	neutral face		Um
20	expressionless face		Hm
21	face without mouth		Jut jut jut
22	smirking face		Aeu heu
23	unamused face		Ummm heu
24	face with rolling eyes		Hmmmm
25	grimacing face		Garr garr

Sequence	Descriptions	Melodic Event	Kenya's speech
26	drooling face		Puv
27	nauseated face		U-o
28	sneezing face		Sssue
29	overheated face		Hae hae
30	face with uneven eyes and wavy mouth		Oi
31	dizzy face		Oi oi oi oi
32	confused face		Aemm
33	worried face		Aomm
34	slightly frowning face		Aeuu
35	white frowning face		Hue um
36	face with open mouth		Aow
37	astonished face		Ow
38	frowning face with open mouth		Hue
39	fearful face		Haa
40	crying face		Suet suet
41	loudly crying face		Nge nge nge
42	face screaming in fear		Ow not
43	disappointed face		Hm
44	tired face		Akkk
45	yawning face		How
46	face with look of triumph		Heu
47	pouting face		Hum hum hum hum
48	serious face with symbols covering mouth		#ก%ๆ@แพร์

[Abstract in Korean | 국문 요약]
음향데이터화를 통해 이모티콘을 듣다

키티판 얀부알라

이 글은 데이터의 소리화를 위해 이모티콘을 입력 이미지로 사용한 데이터 해석을 주제로 하는 저자의 실험적인 시청각 프로젝트의 예술적 연구를 간략히 소개한다. 프로젝트의 정의, 연구배경, 그리고 청각화audification, 각 변수의 연결구도(파라미터 매핑), 청각적 아이콘, 컴퓨터 음성신호earcon를 비롯한 소리화 기술의 사용에 대하여 예술적인 목적으로 설명한다. 또한 시각적 디자인과 선정된 이모티콘의 입력, 사운드 생성 방법, 사용자 제어 도안도 이 논의에 포함된다.

주제어: 실험 음악, 시청각(오디오비주얼), 이모티콘, 소리화(소니피케이션)

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Luka-chucK: a ChucK-based Glitch Audio Composition Environment

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The Luka-chucK is a glitch audio composition environment that uses the ChucK programming language as its audio engine. It can be used to generate audio fragments or entire works. A user interface is provided using communication to Max/MSP via open sound control. A key motivation for this project is the development of features that allow the user to anticipate and control sonic results that emerge from digital audio glitches, and to increase the compatibility of such sounds with other materials used to compose electroacoustic music. With the interface, users can input data to modify pitch, rhythmic, timbral and textural elements by affecting algorithmic devices such as looping and conditional statements. The glitch sounds can also be modified by conventional tools such as a step sequencer, musical keyboard and the use of low frequency oscillators. The environment includes a number of audio instruments based on techniques such as foldover from aliasing, the use of infrasonic frequency content, and quality factor glitches with resonant filters. The purpose of this paper is to discuss motivations, applications and further work related to the development of the Luka-chucK project.

Keywords: glitch, failure, ChucK, computer music programming.

The use of audio glitches to produce new sound works raises questions about the relationship between the idea of "failure" and the artist's own creative intentions. While some practitioners value sharing control with the machine itself to produce complex results that go beyond their own expectations (Menkman 2010), others seek to domesticate glitch sounds so that they can be controlled within other pitch, timbral, and rhythmic constructs that belong to the artist's compositional methodology.

The tools that I have created for this project sacrifice a certain amount of wildness for this very reason. In my own fixed-media work, for example, there is often a juxtaposition of sound synthesis, field recordings and MIDI instrument samples. The sound material that forms the composition covers a wide spectrum of noise, environmental and conventionally musical sounds. For this reason, one of the goals of this project is to investigate how the parameters of digital audio glitches can become compatible with other materials and integrated into the design of a sound work instead of placed as a referential noise object. Luka-chucK consists of eight instruments for working with glitch audio. They can be used individually or combine to form a kind of digital ensemble. The package includes features that can facilitate global changes and fuel greater interaction between instrument components.

This article discusses the way that glitch aesthetics influenced the development of the project, system design and use of the ChucK language. It provides technical information on the available glitch audio software instruments, and describes possible musical applications using a Max/MSP interface.

Tapestries of Sound

Writings and sound works that use glitch sounds can make the use of malfunction feel subversive. Texts such as Caleb Kelly's *Cracked Media* position glitch as part of a trajectory stemming from earlier explorations of nonmusical sound such as the use of instrumental extended techniques in modern era music and the creation of new instruments by artists such as Luigi Russolo. For Kelly, digital glitches help establish the "noisy project of twentieth century experimental music" (Kelly 2009). In *The Aesthetics of Failure*, Kim Cascone emphasizes that glitch sounds can work within a wider expressive range, producing both horrible noise and "wondrous tapestries of sound" (Cascone 2000).

A project that seeks to control glitch sounds may conflict with established historical or aesthetic relationships between failure and indeterminacy. This is outweighed by a motivation to provide a resource that makes glitch audio accessible to practitioners outside of experimental electronic music that may work with more conventional ideas about musical constructs that relate to duration and frequency. For the purposes of this project, a digital audio glitch can be understood as a sound that is derived from a computer's failure to represent the intended or expected sonic result of a signal, instrument or technique.

General Design and the use of ChucK

The Luka-chucK environment exists in a fuzzy space between program, system and instrument or meta-instrument. The design was influenced by other projects that use the capabilities of a particular computer music software or language to create a platform for exploring a specific set of techniques. Examples include Kazuaki Shiota's Max/MSP-based *TranSpell* system for composing based on overtone extraction (Shiota 2007), and the

SuperCollider-based SuperSampler for computer-assisted improvisation (Wu 2017). I refer to the set of tools as an environment because of the way that more global conditions can be imposed on the behaviour of the instruments.

This environment is mostly reliant on ChucK for generating audio and controlling time. Max/MSP is used because it offers a far greater collection of objects for designing a user interface than available in the MAUI API for Chuck's miniAudicle IDE. Many of the instruments in the Luka-chucK are based on the exploitation of thresholds, in particular the acceptable input for methods belonging to the UGens included in recent releases of the ChucK language. Such misuse often results in relative, not absolute control over time. The flexible approach for asserting control over time in ChucK revolves around the ability to forward time using the "now" keyword. Framing events around "now" makes the language well-suited for dealing with unpredictable sounds that result in an ambiguous relationship between duration and frequency parameters. For example, in Figure 1., the use of an infrasonic frequency argument and lower than expected .bodySize can make delay lines used to construct a physical model from the Mandolin UGen more audible.

The majority of the audio glitches in this environment rely on synthesis-based ChucK UGens. The use of recorded sounds was avoided as the complex harmonic spectra of acoustic sound sources might obstruct the ability to control the resultant glitches. Oscillators, impulses and physical models proved easier for testing.

```
[0.00001,0.001,0.05,0.1] @=> float lowSizeArr[];

fun void notMandoInit()

{
  for (0 => int b; b < notMando.cap()-1; b++)
  {

   mandoGain => mando.gain;


   5 => notMando[b].freq;
   lowSizeArr[b] => notMando[b].bodySize;


   0.9 => notMando.pluck;
   0.3 => notMando.stringDetune;
```

Figure 1. Some default settings for the *notMando* instrument

Each glitch instrument uses the chubgraph class to develop objects that can be used with the same level of autonomy as any UGen that is native to ChucK. Chubgraphs are meant to reconfigure existing UGens and functions. Creating chubgraphs based on DSP glitches complicates the intended purpose of this feature of the language. The instruments of the Luka-chucK reveal new synthesis or processing capabilities that are not programmed into the source code for each UGen. This approach to creating glitch instruments circumvents the necessity of advanced programming skills for the development of new audio resources within the language.

```
UGen ensemble[7];//

for (0 => int f; f < 7; f++)
{
    filtGlitch[f] => ensemble[f];
    foldoverPitch[f] => ensemble[f];
    clickCloud[f] => ensemble[f];
    notbandLim[f] => ensemble[f];
    panGrain[f] => ensemble[f];
    noMando[f] => ensemble[f];
    noWG[f] => ensemble[f];
    noBow[f] => ensemble[f];

}
```

Figure 2. Graph demo of system design

The code in Figure 2 points to how instruments can interact within the environment. Passing each instrument into an "ensemble" array increases the possibility for exchanging arguments and output between instruments. A set of mapping functions are used to share the .last() (last sample amplitude) that exists in most ChucK UGens. The best possible approach for the mapping of wider sets of data between UGens is an important part of the future work for this environment. The Event class is used for sharing more asynchronous data between instruments such as noteOn messages.

Overview of Glitch Instruments

This environment consists of eight glitch instruments. The guiding principle in the creation of each one is the exploitation of a threshold. Some play with thresholds based on digital audio theory such as the Nyquist frequency. Others play with thresholds set for input to UGen methods. Others play with perceptual thresholds (i.e. the expectations for the sound of a physical model).

Instrument Name	**Source of Malfunction**
resonGlitch	filter Q, infrasonic Hz
foldPitch	aliasing, ultrasonic Hz
clickHarm	impulsive noise
notBLit	aliasing, ultrasonicHz
microPan	impulsive noise
notMando	Manipulation of bodySize
notWG	Manipulation of pluck
notBowed	Manipulation of vibratoFreq

Table 1. List of Instruments with main sources of malfunction

Each instrument contains a “shifts” function that performs speed manipulation and pitch shifting, mostly using the LiSa live sampling utility UGen that comes with ChucK. The purpose of this function is to provide a level of control where malfunction may affect the frequency (.freq) method of UGens within the Chubgraph, or create difficulties when trying to pass the Chubraph class to processing UGens in a signal path before reaching the dac. For example, certain instruments included in the environment cause the.freq method of UGens within the Chubgraph to affect frequency/pitch in unpredictable or non-linear way. The figure below demonstrates how the clickHarmonizer instrument is shifted down using multiplication of 0.33 (transposing the sound by about a perfect 12th interval), with a wet/dry mix of 0.2 (20%), at a playback rate of 9.0 (9x the original rate).

```
clickHarmonizer clicky => dac;

clicky.shifts(0.33, 0.2,9.0);
```

Figure 3. resonGlitch requires very low gain to be audible (not harmful) and not distorted from clipping

1. *resonGlitch*

The resonGlitch was my first encounter with digital audio malfunction in ChucK. The module is based on the routing of an oscillator (sine, triangle or pulse wave) through a resonant bandpass filter. The main cause of the malfunction is the use of a value less than 1 for the Q (quality factor) method of the ResonZ UGen. When active, the wave is audibly distorted from the original sine shape and its frequency bends fluidly with little predictability.

In terms of controlling the glitch sound, the use of infrasonic frequencies for the oscillator controls the duration of each “chirping” sound within the frame of the value passed to the “now” keyword in ChucK. In this case “now” is acting as a kind of refresh button, controlling time on a larger scale, where the value of SinOsc controls the duration of rhythmic units within the time frame of “now.” Specific frequencies cannot be controlled but more general pitch contours can be heard with the use of the ResonZ .freq method. The frequency of the oscillator can also be assigned as a quarter, eighth, etc. duration according to the public tempo clock class in the environment.

Having the filter Q set to a value less than 1 is integral, and the closer the Q is to zero works much like it would with the conventional application of a resonant bandpass filter, adding an amplified sense of resonance. The actual frequency of the glitch sound does not follow the value passed to the resonant bandpass filter but this argument can be used to transpose the sound up or down in a more general way. The effect becomes audible above approximately 5000Hz.

```
function void filterGlitch(int chirpDurHi, int churpDurLo, float inQ)
   {

        Math.random2(chirpDurHi,chirpDurLo) => s.freq;
        Math.random2(8000,10000) => rez.freq;
        inQ => rez.Q; // default Q

function void amp(float ugenGain) //
   {
    (ugenGain * 10) * 0.0000000000001 => gain1.gain;

   }
}
```

Figure 4. resonGlitch requires very low gain to be audible (not harmful) and not distorted from clipping

2. *foldPitch*

The use of foldover resulting from aliasing is a common glitch audio technique. Computer music composers such as James Dashow have experimented with the control of foldover to form pitch hierarchies through the organization of these sounds into triads (Dashow 1978). The foldPitch instrument does not introduce any new ideas about the production of foldover itself but does have some built-in functions for controlling pitch content with a high degree of specificity.

In addition to specifying pitch classes using linear octave or MIDI note values, strings for triads and seventh chords, polychords and clusters are available within foldPitch. The use of varied pitch converters with the foldPitch was inspired by the MIDI processing in the DAW LMMS (Giblock/ Junghans 2004), which tries to emulate this broad inclusion of pitch collections in and outside of standard tonal/modal music approach.

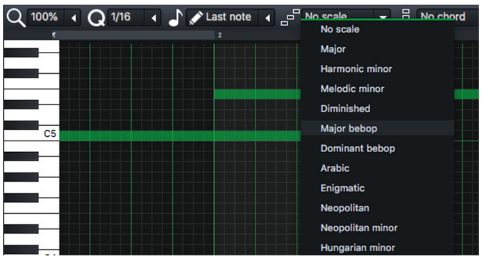

Figure 5. Arpeggiation based on scales or modes in LMMS

```
for (0 => int f; f < foldME.cap()-1; f++)
{
    1 => foldPitch[0].randOsc;
    2 => foldPitch[0].wave;
    "7th chord" => foldPitch[0].mode;
    "Gm7" => foldPitch[0].freq;
    "A5" => foldPitch[4].freq;

    tempo.quarter => now;
}
```

Figure 6. Accessing Pitch Collections in *foldPitch*

In Figure 6, an array of PulseOsc UGens (selected using the .wave method of the foldPitch class are used. When the .mode method is given a triad of seventh chord it assigns the .freq of the specified array member along with the next 2-3 members, to form the chord. This particular chubgraph was used in my 2015 piece *My Metal Bird Can Sing*, in which it was juxtaposed against pitches played into the Logic Pro synthesizer Sculpture using a MIDI keyboard. The foldPitch instrument offers a flexible framework in which a composer is able to use foldover to construct pitch collections that emphasize their personal or cultural location through sound.

```
["C7","D7","E7","F7","G7","A7","B7"] @=> string chordSymbols7th[];
["C#7","D#7","F#7","G#7","A#7","hi","bye"] @=> string chordSymbolsAccidentals7th[];  // Mm7 i.e. Dom 7th

["Cdim7","Ddim7","Edim7","Fdim7","Gdim7","Adim7","Bdim7"] @=> string chordSymbolsDim7th[];
["C#dim7","D#dim7","F#dim7","G#dim7","A#dim7","hi","bye"] @=> string chordSymbolsAccidentalsDim7th[];  // fully dim7

[65.41,73.42,82.41,87.31,98.00,110.00,123.47] @=> float basePchesDiatonic[];
[69.30,77.78,77.78,92.50,103.83,116.54,0.0,0.0] @=> float basePchesChromatic[]; // two extra 0.0 so array sizes all match

float majorRoot;
float minorRoot;
```

Figure 7. Examples of arrays for constructing pitch collections in *foldPitch*

String indicates a chord type - e.g. "Cmaj"

```
/// CHORD SYMBOLS  -- for the "accidentals" version I had to fill two more members "hi" "bye
["Cmaj","Dmaj","Emaj","Fmaj","Gmaj","Amaj","Bmaj"] @=> string chordSymbols[];
["C#maj","D#maj","F#maj","G#maj","A#maj","hi", "bye"] @=> string chordSymbolsAccidentals[];
```

The string is matched to a corresponding frequency to create the root of the chord

```
for (0 => int h; h < 7; h++) //
{

    if (chordType == chordSymbols[h])
    {basePchesDiatonic[h] =>  majorRoot;
```

Voicings are created when the root is multiplied by array contents and distributed to the .freq of a bank of oscillators

```
[1.0,1.5,2.0,2.66,3.0,4.0] @=> float major[]; // assigns
[1.0,1.5,2.0,2.5,3.0,4.0] @=> float minor[];
[1.0,1.37,2.0,2.5,2.74,4.0] @=> float dim[];
[1.0,1.58,2.0,2.66,3.15,4.0] @=> float aug[];
[1.0,1.5,2.0,2.66, 3.5,4.0] @=> float domSeventh[];
[1.0,1.37,2.5,2.75,4.0,2.625] @=> float dim7th[];

if (rootType == majorRoot)
   for (0 => int f; f < 5; f++)
  {
     24000 + (majorRoot * major[f]) => inst0[f].freq;
```

Figure 8. Process for voicing chords in *foldPitch*

The triads, seventh chords and clusters of my foldPitch instrument simply result from multiplying a base frequency against a set of values stored in the array (see Figure 7). Various modes and sonorities that are less referential of major-minor tonality could be implemented according using the same approach.

3. *clickHarmonizer*

This instrument is based on the click heard from impulsive noise, the signal discontinuity created when the frequency argument of a filter is changed instantaneously. The amplitude of the clicks is greater than that of the filtered SinOsc. This difference is exploited using a noise gate to "harmonize" the artifacts, applying pitch shifting and/or comb filters to signal above a threshold. The glitches are controlled by imposing pitch relationships through comb filter delay time and the degree of pitch shifting in the "shifts" function. The instrument is meant to produce a crackly cloud-like texture but can be used for well- defined gestures. While an instrument like foldPitch is highly compatible with the more familiar pitch structures from tonal and modal music, the dense, heterophonic texture produced by clickHarmonizer makes the instrument well-suited for composing highly gestural music that is focused on pitch as it relates to general shapes and contours.

4. *notBLit*

notBLit is based on the band limited sawtooth wave oscillator from the Synthesis Toolkit (Cook and Scavone, 1995) that is included as a UGen in ChucK. Malfunction from misuse occurs is in the relationship between the .harmonics (harmonics in the passband) and the .freq method of the oscillator. Using values above the sampling rate for the harmonics function causes the UGen to sound like a mix of quasi-synchronous impulses (the length of the train depends on the time passed to "now"), along with distorted sounds from foldover. The instrument can be controlled with .freq values above about 90Hz produce different streams and rhythmic grooves. In the 1-100Hz creates predictable streams of impulses rates but the grooves produced by higher frequency input possess a more ambiguous relationship between time and frequency. Connections can be made within smaller bands. For example, from 251-260Hz the groove speed increases. Arrays could be used to store frequencies that produce similar sounds in the 100-199Hz range but this feature does not exist at present. An important next step for the development instrument is the codification of frequencies that produced similar results.

5. *microPan*

Recent computer music tools have begun to explore microsound in domains outside of traditional granular synthesis, such as spectral processing (Norris 2015). As grain sounds tend to become microsonic below a duration of 100ms, the microPan instrument uses signal discontinuities created by randomizing the Pan2 UGen at a rate below 100ms. The signal after the randomized panning is sent to a pitch shifter so that it is more audible compared to the Pan2 input (an oscillator UGen). The oscillator is present because Pan2 needs a signal to malfunction and does not create glitches alone. Its frequency can be infrasonic, ultrasonic or within a normal range. The pitch shifting is what controls the contour of the sound. Exact frequencies of the glitch sounds produced by this instrument can be understood using a function within the chubgraph for pitch detection based on the PitchTrack class from the set of new UGens from CCRMA chugins page on GitHub. In granular synthesis the single grain itself is trivial compared to the manner in which larger groups are layered (Truax, 1988). With the microPan instrument the computer musician also has to think about sculpting larger textures and timbres through manipulations of microsonic durations and inter-grain delays.

As is the case with traditional approaches to granular synthesis, the use of an amplitude envelope for individual grains has a substantial effect on the overall timbre of a stream or cloud-like texture. Replacing smooth, symmetrical curves with abstract shapes (see Figure 9.) can drastically shape the sound output. In microPan, in addition to the default randomization of panning, the instrument has some capability for using a microsonic panning envelope using a combination of a low-frequency oscillator synced to the grain rate and a wavetable oscillator (that creates the table shape) using the GenX Ugen from ChucK.

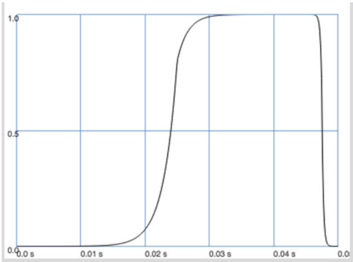

Figure 9. Atypical grain envelope shapes can be applied to microsonic panning

6. *notMando*

The final three instruments in the environment use ChucK UGens based on physical models from the STK. The use of these models within the environment is not about improving them by adding envelopes, filters, delays or convolution to create more effective realizations of the instrument (Kapur et al. 2015). It is focused on investigating how parameters that relate to articulation and timbre can be used to drive pitch or duration.

The notMando instrument extends the mandolin model from the STK. The .bodySize method should take a float between 0.1 and 1.0 to create a perceptually larger or smaller mandolin. The use of particularly small floating point values for .bodySize can create audible echoing effects. Coupled with low (but still audible) frequencies around the 40-70Hz range also adds distortion. The notMando class offers .attack and decay methods that control the intensity of echo and drone durations (see Figure 10).

```
notMando mike2 => dac;

nm.decayLevel(1.25); // 0 - ~ 1.3
nm.attack(0.1); // 0- ~ 1.3
nm.shifts(3.0, 0.3,1.5);
```

Figure 10. New method functions demonstrate how the physical model is repurposed as an electronic drone instrument.

7. *notWG*

This instrument repurposes the BandedWG Ugen that models struck and bowed percussion instruments such as the Tibetan bowl. The .pluck and .bowPressure methods of the BandedWG model are typically adjusted for a more realistic performance, but in the case of this instrument the parameters are modulated using an LFO. An audible sweep of signal discontinuities and artifacts follows the shape of the LFO curve and when given a frequency above 20Hz, the oscillator can be used to provide pitched material from modulating the parameters. The instrument works well with infrasonic frequency arguments passed to the .freq method of the BandedWG Ugen. This adds another level of pitch control but does not follow a predictable pattern. For example, a frequency of 15Hz will sound higher than 16Hz. With unpredictable and non-linear pitch relationships and sudden grooves emerging from one Hz value to the next, the notWG instrument demonstrates the manner in which glitch techniques blur the lines between the pitch and time domains. For example, using infrasonic frequencies via low pitch shift values can expose hidden rhythmic features that are not audible in when the instrument components are intentionally set to produce content well above 20Hz.

```
wave.shifts(2.66,0.4,0.75);
wave.newNote(0.1,0.01); // (loop dur, pitch shift)
wave.lfoParams(10, 0.1);
```

Figure 11. Using pitch shifting to produce infrasonic frequencies that unearth more rhythmic complexity in looped grooves

8. *notBowed*

This instrument uses the bowed string model from the STK. This chubgraph repurposes the vibrato and vibrato gain functions of the original UGen. When the vibrato frequency is used approximately between 50-100Hz, it begins to produce pulsating grooves with speeds that can be controlled using the vibrato gain level. As is the case with notBLit, this instrument offers more relative than definite control of parameters. Pairs of .vibratoFreq and .vibratoGain values could be stored in arrays for later use. While *notBowed* relies heavily on beating from interference of waves, a well-established technique within electronic and computer music, the misuse and repurposing of methods for playing the synthesized representation of a bowed instrument demonstrates a “glitching” upon the notion of a model.

Communication with Max/MSP

While the components of this environment can be used solely with text in chucK, the use of a user interface designed in Max/MSP is the place where this project becomes less a set of instruments and more of an environment for creating new sound works. This component features large-scale conditions such as the use of a LFO's and an ADSR envelope to manipulate the overall output gain, a slider that can condense the general width of certain random number generators in chucK, and the ability to record audio output into buffers, playback, mix and write to files.

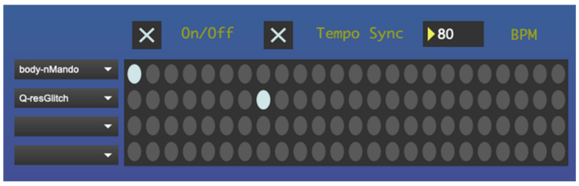

Figure 12. Sequencer using Max

The step sequencer offers grid-based manipulation of parameters belonging to each instrument, with independent event streams of up to four parameters at a time. For example, the quality factor of the resonGlitch and the bodySize of notMando can rely on the same pattern or take on individual streams. If this component is on, values move across the matrix, activated once selected from umenu objects.

A subpatcher called "routingParams" allows for the mapping of parameters across certain instruments. Extracting and storing information from active instruments is an important part of the development of this project from a set of tools into an environment. For example, the root of a chord specified for foldPitch can be mapped to the pitch array used for notMando by calling the .freq function of the oscillators within foldPitch. The use of OSC messaging allows UI some limited control over mapping of parameters. At present the mapping is limited in terms of the degree to which parameters can be exchanged. For example, the STK UGens share certain methods (e.g. noteOn) that are not present in the oscillator UGens. The majority of UGens have .freq, .gain and .last methods that can be useful in this context. Mappings should be chosen carefully to avoid interfering with the sequencer.

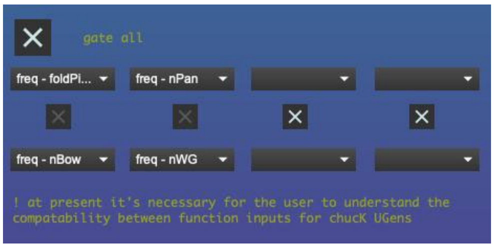

Figure 13. Routing parameters to create interdependency between instruments

The environment also allows the user to reconfigure some algorithmic processes within the ChucK code using number boxes and dials. For example, the user can trigger timed events specified using a for loop, specifying the number of iterations, time passed to "now" in ChucK and mapping of the loop control variable. At present the best results for creating sound with this environment come from combined use of the Max/MSP UI and the ChucK code.

Conclusion and Future Work

By exploiting digital audio thresholds and repurposing the function methods of UGens in the ChucK language the instruments in the Luka-chucK environment provide the user with a wide expressive palette based on sounds that are not readily available using other common synthesis and processing techniques. The use of digital audio failure in this environment is not focused on the glitch as a catastrophe that must be distinct from the regular function of the system (Betancourt 2016), but seeks to investigate the expressive potential for glitches outside of their designation as noise sounds.

Future work includes the incorporation of MIR features such as the use of real time quantization between events, concatenative sampler synthesizer to increase the compatibility between the sounds produced by the environment and by other electronic music elements within ChucK, or even live sampling of acoustic instruments.

The reduction of audio glitches to pitch/timbral and rhythmic constructs that I have used in my own compositional output often deal with scales, modes, chords and temporal units mostly found in tonal and modal music. An important addition to this project would be the ability to map these sounds to structural elements that are common to music within other cultural spheres. There is already important work being done in exploring the compatibility between computer music and nonwestern traditions. For example, the Virtual Gamelan Graz projects features event scheduling that allows for gradual transitions that are idiomatic when performing gamelan music (Grupe 2008). Such features would help extend the environment beyond my own creative practice and hopefully provide a meaningful resource for other artists.

Documentation and audio examples can be found at https://www.michaellukaszuk.com/music-tech.

References

Betancourt, M. (2016). *Glitch Art in Theory and Practice: Critical Failures and Post-Digital Aesthetics.* Routledge.

Cascone, K. (2000). The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music. *Computer Music Journal 24*/4: 12-18.

Cook, P. R., and Scavone, G. (1995). The Synthesis Toolkit in C++ [Computer software]. https://ccrma.stanford.edu/software/stk/

Dashow, J. (1978). Three methods for the digital synthesis of Chordal structures with non-harmonic partials. *Journal of New Music Research 7/*2-3: 69-94.

Gilblock, P./ Junghans, T. (2004). LMMS [Computer software]. https://github.com/LMMS/lmms

Grupe, G. (2008). *Virtual Gamelan Graz*. Shaker Verlag.

Kapur, A./ Cook, P./ Salazar, S./ Wang, G. (2015). *Programming for Musicians and Digital Artists: Creating music with ChucK*. Shelter Island: Manning Publications.

Kelly, C. (2009). *Cracked Media: The Sound of Malfunction.* MIT Press.

Norris, M. (2015). *Soundmagic Spectral* [Computer software]. https://www.michaelnorris.info/software/soundmagic-spectral

Rosa M. (2010). *glitches vs glitch art*. http://rosa-menkman.blogspot.com/2010/04/glitches-vs-glitch-art.html

Shiota, K. (2007). "{TranSpell} ". In *Proceedings of the International Computer Music Conference*, Copenhagen, Denmark, 355-359.

Truax, B. (1988). Real-Time Granular Synthesis with a Digital Signal Processor. *Computer Music Journal 12*/2: 14-26.

Wu, A. (2017). SuperSampler: A New Polyphonic Concatenative Sampler Synthesizer in SuperCollider for Sound Motive Creating, Live Coding, and Improvisation. In *Proceedings of the International Computer Music Conference*, Shanghai, 210-215.

[Abstract in Korean | 국문 요약]
루카-추크: 추크를 기반으로 한 글리치 오디오 작곡 환경

마이클 루카스추크

루카-추크Luka-chucK는 추크ChucK 프로그램 언어를 오디오 엔진으로 사용하는 작은결함(글리치) 오디오 작곡 환경이다. 작은 소리 조각부터 전체 작품을 만드는데 사용할 수 있다. 사용자 인터페이스는 오픈 사운드 컨트롤을 거쳐 맥스/엠에스피Max/MSP와 통신을 통해 마련된다. 이 프로젝트의 핵심 동기는 작은 디지털 오디오 문제로 야기되는 소리를 사용자가 예측 및 제어하는 기능을 개발하고, 전자음악을 작곡할 때 사용되는 다른 재료들과 그러한 소리들 사이의 호환성을 높이기 위함이다. 인터페이스를 통해, 사용자는 순환식looping이나 조건적 명령 같은 알고리듬 장치를 작동시킴으로써 음고와 리듬, 음색, 질감적 요소를 조절하는 정보를 입력한다. 글리치 사운드는 또한 스텝 시퀀서나 뮤직 키보드, 저주파 발진기 사용 같은 기존의 도구로도 변형시킬 수 있다. 오디오 작곡 환경에는 겹침오류(앨리어싱으로 인한 폴드오버), 초저주파 주파수 요소 활용, 공명 필터가 달린 음질 요인 글리치와 같은 기술 기반의 많은 오디오 기기들이 포함될 수 있다. 이 글의 의도는 루카-추크 플로젝트 개발과 관련된 연구 동기와 그 응용 내용, 추가 작업에 대하여 논하는 것이다.

주제어: 글리치, 결함, 추크, 컴퓨터 음악 프로그래밍

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Collaborative Creation with Soundcool for Socially Distanced Education

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Soundcool is a flexible, modular computer music software system created for music education. Moreover, Soundcool is an educational approach that embraces collaboration and discovery in which the teacher serves as a mentor for project-based learning. To enable collaboration, Soundcool was designed from the beginning to allow individual modules to be controlled over Wi-Fi using smartphone and tablet apps. This collaborative feature has enabled network-based performance over long distances. In particular, the recent demand for social distancing motivated further explorations to use Soundcool for distance education and to enable young musicians to perform together in a creative way. We describe the educational approach of Soundcool, experience with network performances with children, and future plans for a web-based social-network-inspired collaborative music creation system.

Keywords: Collaborative Creation, Education, Social Distance, COVID.

Soundcool is a free system for collaborative Sound and visual creation that has received several awards and has been invited by the World Science Festival 2019 in New York. See Scarani et al. (2020) and Sastre and Dannenberg (2020) and the references therein for a complete explanation. The Soundcool system offers different modules such as audio and video sources (live audio and video inputs, players, hosts of VST virtual instruments, signal generators), audio and video effects, mixers, video switchers, etc. (See Figure 1). These modules run on personal computers with the possibility for control via Android or iOS smartphones and tablets (see Figure 2), or other devices using the Open Sound Control (OSC) protocol. The system has been used in several education projects in America and in European Erasmus+ education projects, in schools and universities (Sastre/ Dannenberg 2020). The connection of the control devices is typically done using a local area network based on a Wi-Fi hub. However, with students and even teachers confined at home because of the COVID-19 situation and online education, we realized that the networking capabilities of Soundcool could be helpful in distance education.

In 2016 we developed a system allowing telematic performances with Soundcool through the Internet (Scarani et al. 2020). We performed a concert called the GlobalNet Orchestra, with participants at Carnegie Mellon University (CMU) and the Universitat Politècnica de València (UPV) (see globalnetorchestra.blogs.upv.es/). However, this system was too complicated to be used generally and quickly, and we have developed a simpler system for online collaborative creation at a distance. We have tested this approach by recording several performances with students and teachers working from their homes, showing that the system can be used even in the more restricted situation of COVID-19 confinement.

Figure 1. Soundcool 4.0 computer launcher showing Soundcool modules.

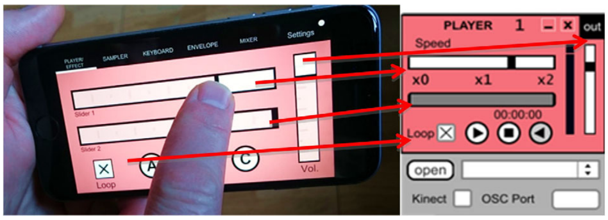

Figure 2. Control of the Soundcool modules with smartphones.

Online collaborative creation and performance

Soundcool was used for a telematic performance between CMU and UPV in 2016. In this performance, our goal was high-quality sound at both performance sites and reliable transmission of parameters in real-time, even at the expense of some added latency.

To deliver high-quality sound, we duplicated the local Soundcool configuration at the remote site. The idea was to deliver the same OSC control messages to a “mirror” Soundcool server so that, aside from small timing variations, the synthesized sounds would be the same, and we would not need to send high-bandwidth audio over the network. The network would transmit only control information.

Normally, OSC is transmitted over the UDP protocol, which is a “best effort” protocol in which messages may be dropped due to network contention or transmission errors. (Peterson/ Davie 2012) While this is a minor problem in a local network, packet loss can be disruptive over long distances and many “hops” (forwarding retransmissions) as packets transit multiple networks. To ensure reliable transmission, we created simple software to receive OSC locally, forward the messages to the local Soundcool server over UDP, and forward messages to the remote site using a reliable TCP protocol. (TCP uses acknowledgements, retransmission and sequence numbers to guarantee in-order, loss-free delivery of data at the expense of added delay whenever a lost packet must be retransmitted.) Once the messages arrive at the remote site, they are forwarded locally to Soundcool via UDP, making the control system totally transparent to the Soundcool servers, but allowing users to control both servers as one. (See Figure 3.)

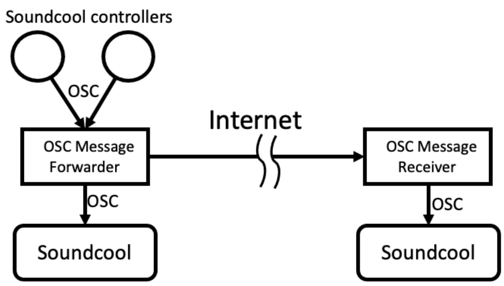

Figure 3. For network performance, controls for local Soundcool application are duplicated and transmitted reliably to a remote site, where duplicate OSC messages are constructed and forwarded to another “mirror” Soundcool configuration.

As the pandemic isolated teachers and students, we looked for a simple way to use Soundcool. Videoconference systems like Zoom allow a single Soundcool server to send sound to all participants with minimal setup since participants are already connected by videoconference. Participants need only send OSC messages from smartphones and tablets to the Server to enable real-time collaboration. Aside from packet loss, the main difficulty is that Soundcool network ports are not immediately accessible over the Internet due to standard security precautions in ordinary home routers. However, it is not difficult to reconfigure typical home routers to allow receipt of UDP messages with specific port numbers. Only the teacher running Soundcool needs to do this because routers only block *incoming* traffic, not *outgoing* messages from students. Once ports are opened, students from anywhere on the Internet can control Soundcool, given the Soundcool program’s Internet IP address and the proper port numbers.

A drawback of the UDP protocol, again, is that it does not guarantee that messages are delivered. Tests should be conducted to see if the rate of lost messages is low enough for educational applications. Our first test was done on June 14, 2020 in a Webinar with the Association of Music Teachers of the Murcia Region (ADMURM, Spain) where a Soundcool program running in Valencia was controlled by a teacher and her smartphone in the city of Murcia, at a distance of about 200 km. (youtu.be/B4I3G2YCG-s?t=1736) (See Figure 4.)

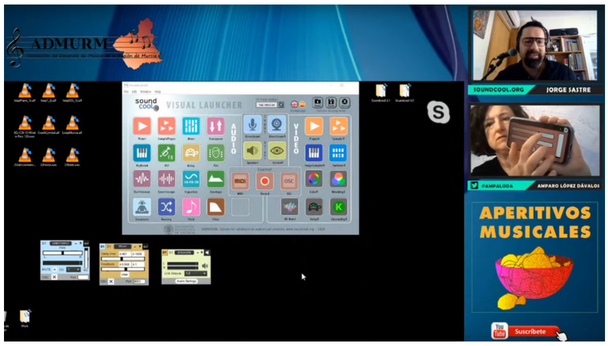

Figure 4. Control of Soundcool in a PC in Valencia from a smartphone in Murcia, Webinar ADMURM (Spain), June 14th, 2020.

Our first telematic performance with the new system featured a collaborative creation with participants from their homes in Madrid and Valencia in Spain, and Pittsburgh in the USA, on June 17, 2020. It was a Remix of the famous Kraftwerk's “The Robots,” which was proposed by Jesús Jara, director of the Escuela Municipal de Música y Danza María Dolores Pradera (Madrid, Spain). Participants included his young Sonotronic (curriculum) students, another teacher from the school, Juan Manuel Escalera, and Roger Dannenberg, Stefano Scarani, Saúl Moncho, Manuel Sáez and Jorge Sastre from the Soundcool team. Jesús and the computer with Soundcool were at the school, and he shared his screen with all the participants over a Zoom videoconference. The performance was based on triggering samples by the participants, creating a soundtrack for the video, which is taken from the animation “Superman: The Mechanical Monsters” (1941). Participants also controlled the cut-off frequency of a low-pass filter, some effects, and mixer levels. See Figure 5 and youtu.be/O8IRLvGZnb8 (English subtitles available).

The delay and UDP packet loss rate was noticeable but acceptable. From Pittsburgh (worst case), we can measure less than 1% of packets are lost and average round-trip time is about 120 ms. Perhaps due to Zoom and multiple OSC connections, we estimate the loss to be closer to 20% and adding the delay of Zoom makes the response time around 0.5 s. The packet loss can be mitigated by making slow control changes and finishing each gesture with a few small changes, since every small change sends another packet, and at least one out of every few packets is highly likely to get through.

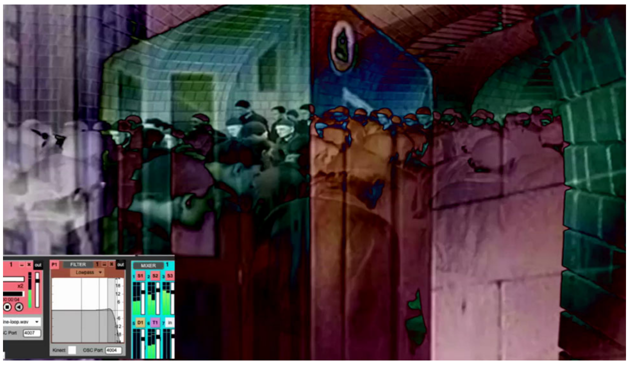

Figure 5. Kraftwerk Remix performance with participants controlling a Soundcool filter, a mixer, players and effects (some of them are shown bottom left) from Madrid and Valencia (Spain) and Pittsburgh (USA), June 17th, 2020.

At the end of July, we offered an online course on collaborative music and audio-visual creation with Soundcool for socially distanced education, and there we challenged the students to make a TV show as the final course work. It consisted of a piece of news and a concert called Crónicas Terrícolas (Earth Chronicles). This time we used Microsoft TEAMS for the course videoconference. (See Figure 6.) One of the participants from Valencia (Spain) controlled a video switcher (top right of Figure 6) to change the video source according to the TV show structure.

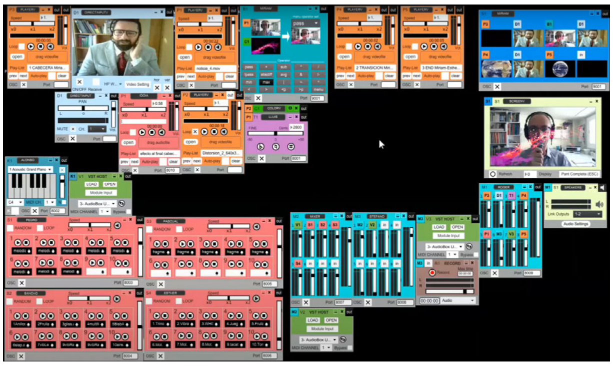

Figure 6. Soundcool patch for the Earth Chronicles show with participants in several cities in Spain and Pittsburgh (USA), July 28th, 2020. The patch includes four (4) sample players (lower left), mixers, video players, a video switcher and multiple audio and video effects processors. Patching (not visible) is by clicking an output button and input button in sequence. These buttons and connection indications are generally in the upper left and right corners of modules.

The TV show video could be seen in full screen, however we preferred that the participants see the TV show in a small window so that they could also see how they controlled the Soundcool modules from their homes. The central computer with Soundcool was at Sastre's office in Valencia. He was the TV show announcer using the live video from a webcam. In the following we explain the work that can be seen at youtu.be/rXQ73PWxzSk (English subtitles available). The piece of news part was triggered by a sound at audio player (P1, Red color) controlled from the Basque Country (Spain) as a sudden alarm sound. It was about a computer virus infecting computers in Catalonia (Spain), the location of the participant who proposed this part. He recorded video previously, which we played at the central Soundcool computer. To represent a virus, the participant controlled a transposing effect applied to the video voice and a participant from Valencia (Spain) controlled video blending with another video (controls are visible at top center, and result is visible at the right of Figure 6). After that, a musical performance took place. Melodies and extended techniques for clarinet and flute had been previously composed and recorded by the participants. The quantity of granular synthesis VST delay effect applied to the music was controlled by Stefano Scarani in Valencia along the piece, and Roger Dannenberg controlled the final mixer levels for the whole TV show with his smartphone connected from Pittsburgh (USA). The piece was improvised in sections cued by Sastre's holding up 1 to 5 fingers in sequence:

1) 2:14. The music starts with some improvisations in a virtual instrument (a free vocal type VST) controlled by a participant in Castilla la Mancha (Spain).
2) 2:31. Pentatonic clarinet melodies are played using a Sampleplayer module controlled from Andalusia by their composer. They are mixed with the clarinet extended techniques played by another Sampleplayer from the Madrid Community by the clarinetist that recorded them.
3) 3:17. Atonal melodies from the Valencian Community are played in a third Sampleplayer by their composer and mixed with flute extended techniques from the Murcia Region played in a fourth Sampleplayer by the flutist that recorded them. Also, after in this part at 3:44 there is a sign with both hands for all the participants to stop performing except for the granular synthesis delay, to give variety to the music.
4) 3:54. Again, pentatonic clarinet melodies, but with speed change effects and some more participants performing.
5) 4:42. We end with a return to the VST instrument improvisation and a final granular synthesis delay effect.

Finally, the announcer says goodbye. The entire show consisting of music compositions, recordings, etc. was prepared in a few days. The UDP packet losses and delays, as before, were acceptable for this application, showing that collaborative creation and performance with Soundcool is possible even in a confinement situation. We note that precise timing and rhythmic synchronization are not possible within this approach, but that merely shifts the pedagogical and musical focus to sound textures and music organization at larger time scales. Details at smaller times scales can be addressed through the use of samples with rapid and even rhythmic events.

The role of the teacher in collaborative education

The new teaching paradigm is based on interaction and collaboration between teachers and students. Students locate information when they need it. They have a device in their pocket with which to answer a question at any time. Why then does the teacher have to offer them material that they can find themselves? Collaborative education focuses on the work of the mentor teacher, as a guide to select necessary content, taking into account the students' interests and individual needs. Project learning is essential for this new digital collaborative training. This approach, far from being new, has been known since the middle of the 20th century. The basic levels of Bloom's taxonomy of learning (Bloom 1956) already anticipate this. Knowledge (theory) and the understanding and the application of these theoretical contents (problem solving and practical sessions) are levels that digital technology already provides without the need for a wise teacher to provide them. However, the complex levels of learning, knowledge analysis and synthesis, and innovation are not offered by technology alone. The teacher must be the center of the dynamization of knowledge and must use the means that his students use daily.

For young people, the Internet, social networks and apps constitute very relevant spaces for socialization, encounter, exchange and knowledge. This is why Soundcool has been considered since its inception as a collaborative learning and creation tool where the teacher has a vital importance in the learning and creation process. As Professor Duart says in his editorial "Internet, Social media and Education," "Teachers have the challenge of being permeable to the changes that occur in the communicative environment and social uses of the Internet. The true transformation is found in the educational dynamics, in the educational process that takes place in the classroom and, today more and more, out of it." If you really want to motivate and reach students, you will have to understand their environment and adapt the teaching to it. And this is the fundamental basis for the development of the Soundcool project, especially as an integrator of STEAM (Science, Technology, Engineering, *Arts*, and Mathematics – a broadening of STEM) for student learning. Due to this interest, a large part of the project's efforts has focused on generating tutorial materials for teachers (see Figure 7) so that they can use the tool in the classroom or online as in our last remote connection project. Therefore, several sound, music, audio-visual and multidisciplinary projects are available for teachers in soundcool.org/en/projects/ (see Figure 8), and teacher video tutorials for acoustics and language (Spanish) are available in bit.ly/3lsJibu (see Figure 8). These tutorials have focused on explaining to teachers how to create collaborative training activities with their students using the Soundcool tool, both with all the students in the classroom and with the current social distancing due to the effect of COVID-19.

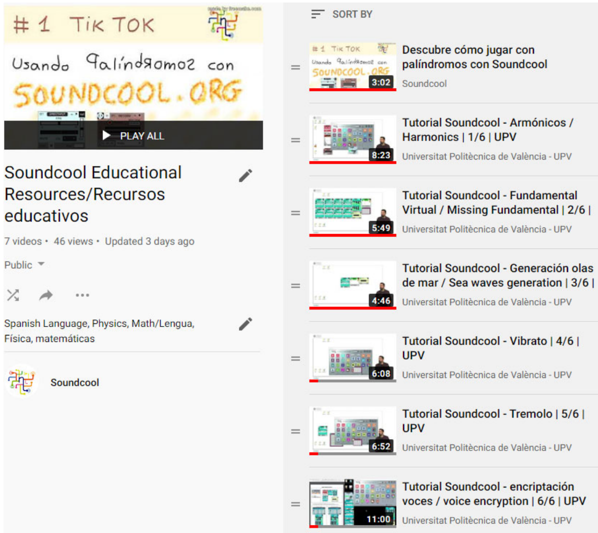

Figure 7. List of Soundcool teacher tutorials.

Figure 8. Basic Soundcool projects as radio workshop, soundtracks, producing and recording loops at soundcool.org/en/projects/.

It has been essential for our project to create not only a tool, which will remain as a mere technological development, but to design a whole model and a teaching methodology that allows teachers to apply this methodology in the classroom. Teachers are encouraged implement technology not as an end but as a means for education and training and to introduce innovation in the classroom through the development of collaborative projects, either in person or in virtual form.

Given the current situation in which we are immersed, students can be reached at any time, but the teacher has to be willing. It makes no sense to close communication with the student outside the classroom, and a collaborative environment must be created that allows this continuous and constant interrelation with all the students, whether in the classroom or in a virtual environment. This is what our tool offers to the teacher: places where the teacher is the center of learning without having to be in the classroom in person and without losing control of the training of their students.

Toward Soundcool as a Social Network

Music is an inherently social process. Soundcool has shifted the focus of electronic music from the individual working alone at a computer to a collaborative design and performance process. As we explore how best to deliver Soundcool conveniently to young users and even non-technical teachers, we have begun a complete re-implementation, moving Soundcool from a Max-based desktop application (cycling74.com/products/max) to a Web Audio application (www.w3.org/TR/webaudio/) running in the browser. We now have the basic modules of Soundcool running in Web Audio (github.com/ rbdannenberg/soundcool), and our goal is to offer a website where anyone can simply open their Web browser in order to use Soundcool.

One advantage of a web-based Soundcool is that users will automatically be interconnected through a shared server. This will enable collaboration through:

- sharing and copying examples, tutorials, and completed works. Students can learn from others or publish their projects to be seen by friends and relatives,
- joint projects can be undertaken by sharing module patches and audio or video samples. Users can compare different versions,
- group performances where each participant downloads and operates a “mirror” of the shared patch. As performers adjust parameters, cue sounds, and make selections, the changes are transmitted through the Soundcool server to all mirrors, and all changes are effected globally.

In this paradigm, it would not be difficult for groups of 2 to 20 play together, even with modest network bandwidth since all audio is generated locally[1]. We expect to make a first release before the end of 2020.

Summary and Conclusions

Soundcool is an easy-to-use but high-quality and very capable system for computer music creation. While intended for young students, Soundcool has found many uses in professional settings due to its combination of flexibility, high-quality sound, and ease of use (see bit.ly/soundcool-pro). Much more than mere technology, Soundcool was designed from the beginning to support collaborative creation, particularly through the simplicity of controlling modules using smartphones, tablets, and Wi-Fi.

The control of Soundcool over Wi-Fi led us to use Soundcool as the basis for collaborative network performances, sending Soundcool audio and screen-sharing to performers using a Zoom videoconference, and using Internet connections from smartphones and tablets to Soundcool for collaborative control by the group.

The collaborations and performances so far have been very encouraging, including a performance with school children from Madrid and with teachers from several cities from Spain. We look forward to more performances.

In the future, we aim to make collaboration and interaction even simpler by creating a web-based version of Soundcool that will be inherently networked and interconnected. This continuation of the Soundcool project will make it even easier to share media, sound design, patches, and real-time collaborative control at a distance.

Soundcool has shown great promise as an innovative approach to music education, a way to expose young students to the possibilities of creative and experimental electronic sound, and a powerful means to enable collaborative creation. Given our current need for social isolation, Soundcool has become a vehicle for bringing young performers together again, by making network performances simple enough for teachers and students without extensive knowledge of networking and computer systems. We look forward to many more possibilities for music and education as we create a Web Audio version of Soundcool.

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References

Bloom, B.S. [Ed.]. Engelhart, M.D./ Furst, E.J./ Hill, W.H./ Krathwohl, D.R. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

Cabrera, M./ Lloret, N./ Poza, J.L. (2020) “Docentes: Mutación o extinción” Telos Fundación Teléfonica. Available from https://www.researchgate.net/publication/339500618_Docentes_Mutacion_o_extincion_Telos_Fundacion_Telefonica [accessed Aug 27 2020].

Duart, J. M. (2009): “Internet, redes sociales y educación” In *RUSC. Universities and Knowledge Society Journal* 6/1 Barcelona, Universitat Oberta de Catalunya.

Peterson, L./ Davie, B. (2012) *Computer Networks: A Systems Approach.* Burlington, MA: Morgan Kaufmann.

Sastre, J./ Dannenberg, R. (2020). “Soundcool: Collaborative sound and visual Creation”, *Sonic Ideas* (*CMMAS*) 12/22: 75-86 (available in Spanish in pp. 63-74).

Scarani, S./ Muñoz, A./ Serquera, J./ Sastre, J./ Dannenberg, R. (2020). “Software for Interactive and Collaborative Creation in the Classroom and Beyond: An Overview of the Soundcool Software.” *Computer Music Journal*, MIT Press. In print.

Wright, M./ Freed, A./ Momeni, A. (2003). “OpenSound control: state of the art 2003.” In *Proceedings of the 2003 Conference on New Interfaces for Musical Expression (NIME- 2003)*: 153–159, Montreal, Canada.

[1] In some situations, it may be practical to stream live audio and/or video from performers in addition to control information, perhaps building on WebRTC (webrtc.org). However, given frequently encountered bandwidth limitations, especially in education, we leave that to future work.

[Abstract in Korean | 국문 요약]
사회적 거리두기 교육을 위한 프로그램 사운드쿨로 합동 창작하기

호르헤 사스트레/ 누리아 로렛/ 스테파노 스크라니/ 로저 비 다넨베르그/ 헤수스 하라

사운드쿨Soundcool은 음악 교육을 위해 제작된 유연하면서 모듈식의 컴퓨터 음악 소프트웨어 시스템이다. 또한, 사운드쿨은 교사가 연구과제 기반의 학습을 지도하는 수업에서 협동과 발견 단계를 아우르는 교육적 접근방법도 가지고 있다. 협동을 실현하기 위해서, 사운드쿨은 처음부터 각 스마트폰이나 태블릿앱을 와이파이를 통해 사용하여 개별 모듈 단위로 제어할 수 있도록 설계되었다. 이러한 협동과정은 장거리에서도 네트워크 기반의 실행이 가능하다. 특히, 최근 사회적 거리두기의 요구로 인해 사운드쿨이 원격 교육에 활용되고 젊은 음악가들이 창의적인 방식으로 함께 공연할 수 있도록 더욱 많은 연구를 시도하였다. 저자들은 사운드쿨의 교육적 접근법과 아이들의 네트워크 공연 경험하기, 웹 기반의 사회적 네트워크 기반 협동 음악 창작 시스템에 대한 향후 계획에 대하여 논의한다.

주제어: 합동 창작, 교육, 사회적 거리두기, 코비드.

논문투고일: 2020년 09월27일
논문심사일: 2020년 12월12일
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Otto Laske and the Visualization of Electro-Acoustic Music: Laske's Visual Music Animations

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Otto Laske (b. 1936), a pioneer of computer music and the founder of "Cognitive Musicology" (which roots in such disciplines as musicology, philosophy, computer science, psychology, linguistics, semiotics, and sociology), combined his research with his artistic activities: initially composition and writing of poetry, later also digital art. This paper provides some biographical, artistic, and research background of Laske's theories to explain his electro-acoustic music (1966-2009) and his artistic fulfillment in the visualization of his electro-acoustic music (2011-2012). For these animations, individual frames became the 'negatives', on which he bases his work in the visual arts. This art is musically inspired throughout, with a focus on flow, tension, conflict, and movement. In his visualizations, animation 'objects' carry visual images or even a sequence of images, and while the images move against and through each other, their colors, shapes, and textures follow the flow of the music. Laske treats an animation still as the visualization of a set of pixel-level parameters that define the shapes, colors, textures, and dynamic characteristics of an image. Working with Cinema 4D, Studio Artist, and Photoshop, Laske's work is highly creative. Several of Laske's Visualizations are being explored and holistically viewed within the framework of his lifework.

Keywords: Otto Laske, electro-acoustic music, visualizations, visual arts.

From the 1970s through the 1990s, Otto Laske was one of the leading scholars in the area of Artificial Intelligence and Music. He is the founder of "Cognitive Musicology," which roots in such disciplines as musicology, philosophy, computer science, psychology, linguistics, semiotics, and sociology. Besides his research in and across these disciplines, Laske combined his research with his artistic activities: composition, especially computer music, and writing of poetry. Such interdisciplinary and inter-artistic thinking was necessary to create the Cognitive Musicology, of which the main focus is on creative processes. In the late 1990s, Laske pursued a Psy.D. in clinical psychology, and in his artistic work focused more and more on visual arts, creating a series of visual animations with computer music.

Laske's research cannot be separated from his various activities throughout his career and from his artistic activities. Therefore, this paper is in two parts: it will provide some biographical notes and then focus on Laske's creative activities, especially the visualization of electro-acoustic music.

Biographical Notes on Otto Laske

Otto Ernst Laske was born on April 23rd, 1936, in Oels (Olesnica), Silesia. Together with his mother and sister, he escaped from the oncoming Soviet army in 1945, which brought him to Lilienthal, near Bremen (Germany), the city in which his mother was born. There, he soon started playing the piano. At age 11, he met his father, who had been a prisoner of war in the Soviet Union; still in a war trauma, Laske tried himself in writing poetry from age 13 on. Although he temporarily interrupted his piano studies and, thus, his musical activities, he never lost the contact to the music, as his family was very music-loving.

After a social-science diploma at the business high school in Bremen (1955) and after one year of administrative work, Laske started studying business administration in Göttingen in 1956. There, stimulated by the Sociological Institute, he started research on sociology. This interest in sociology brought him to the Goethe University in Frankfurt / Main and the Institute for Social Research (Institut für Sozialforschung) with Max Horkheimer and Theodor W. Adorno. While he abandoned his business studies, his sociological interest led him to studying philosophy, which he started (after a second, classical high school diploma) in 1958. In addition, he studied musicology from 1960 on (with professors Helmuth Osthoff, Friedrich Gennrich, and Lothar Hoffmann-Erbrecht) as well as English and American Language and Literature from 1964 on. After intensive studies of Greek philosophy, especially supported by Bruno Liebrucks, Laske wrote his dissertation under the supervision of Theodor W. Adorno on the dialectics of Plato and the early Hegel, which he completed in 1966.

During his academic studies, specifically from 1961 on, Laske continued his music-practical studies, as he picked up composition and studied Hindemth's *Untersuchung im Tonsatz*. From 1963 to 1966, Laske studied composition primarily with Konrad Lechner: first, at the Frankfurt Musikhochschule and later at the Academy of Music in Darmstadt. Besides his studies with Lechner, who specifically continued the tradition of Guillaume de Machaut and Anton Webern, the Darmstadt Summer Courses were very stimulating for Laske's musical developments, where he met composers such as Stockhausen, Ligeti, Boulez, and Babbitt. In Darmstadt, he also met Gottfried Michael Koenig in 1964, which became most crucial for the development of Laske's composition theory and Cognitive Musicology.

After completing his dissertation, Laske was a Fulbright Scholar from 1966 to 1968 at the New England Conservatory in Boston (USA), where he graduated with a Master of Music degree in composition. He then gained teaching positions, each for one year, as visiting professor of philosophy in Ontario (Canada) and as visiting professor of musicology (specifically the music of the Middle Ages, the Renaissance, and the Baroque) at McGill University in Montreal (Canada). Invited by Koenig, Laske taught and studied at the Institute of Sonology in Utrecht (Netherlands) from 1970 to 1975. During the time period from 1971 to 1974, he was holding a fellowship from the Deutsche Forschungsgemeinschaft (German Research Foundation) for the project "The Logical Structure of a Generative Grammar of Music." Besides his collaborations with Koenig and Barry Truax, the training in a classical electronic studio became very important for Laske. Here, influenced by informal studies of computer science (1972-1974), he developed the foundations for his Cognitive Musicology.

After two additional years of studies (1975-1977) in psychology and computer science as a post-doctoral fellow at Carnegie Mellon University in Pittsburgh, Pennsylvania, and after completing a year as guest professor at the University of Illinois in Urbana (1978-1979), Otto Laske's research was extensively focused on Artificial Intelligence. He worked from 1980 through 1985 as software engineer and from 1986 through 1991 – especially in Switzerland, Germany, and The Netherlands – as a consultant for the development of expert systems. In addition, he was a guest professor of computer science for one year at Boston College in Chestnut Hill, Massachusetts. Already since 1984, he was more interested in the process, through which one gathers expert knowledge (to eventually create expert systems with that knowledge), than in programming.

From 1981 through 1991, Laske was – initially with Curtis Roads – artistic director of the New England Computer Music Association (NEWCOMP). During this time, he organized 65 concerts for mixed media and taught courses on computer-assisted composition in Stuttgart (1981), Darmstadt (1981), Boston (1981-1984) and Karlsruhe (1988/89). In 1992, he turned towards developmental and clinical psychology (Harvard University), to gain the theoretical basis for a theory of coaching. From 1996 to 1999, Laske studied clinical psychology at the Massachusetts School of Professional Psychology and received a Doctor of Psychology (Psy.D.) with his dissertation on "Transformative Effects of Coaching on Executives' Professional Agenda" (1999). He founded the consulting form Laske and Associates LLC (2000), and later the Interdevelopmental Institute (2004) – an institute for advanced coaching and cadre education, focusing on dialectical and thinking and transforming organizational structures.

As an artist, Laske has an extensive compositional work, a large output of poetry, and he dedicated himself in recent years to visual arts. Much of his compositional work informed his research on creative processes in music. A Festschrift was published in recognition of his scholarly and compositional work (Tabor 1999).

Laske's Compositional Work

Laske's manifold scholarly activities and, thus, the development of his Cognitive Musicology, are hard to separate from his artistic work (composition as well as poetry), because composition theory is in the center of both areas.

Between 1964 and 1970, Otto Laske composed – under the influence of his teacher Konrad Lechner ("micro-counterpoint") and of Darmstadt (Stockhausen) and Renato de Grandis – only instrumental or vocal music without the computer. However, already his Two Piano Pieces (1967-69) were composed "top down," as later with Koenig's computer program "Project 1." Laske met Koenig in 1964 in Darmstadt, and most stimulating was a lecture by Koenig on composing with computers, which contained the main principles of what later became "Project 1." This program for interpretative composition is the one program to this day that is primarily used by Laske. During the early 1970s, however, Koenig's programs had little practical, but strong theoretical influence on Laske. Influences regarding counterpoint came from Avram David (Boston), while Robert Cogan (Boston) developed Laske's understanding of musical form.

Laske's music of the 1970s was influenced by the classical electronic studio: electroacoustic music was dominating. He mainly used Barry Truax' POD. Many other works were only influenced by the (thinking of the) way in which computer programs work (for instance, Quatre Fascinants for 3 Altos and 3 Tenors, with lyrics by Renee Char, 1971), but only Perturbations for flute, clarinet, violin, violoncello, piano, and 2 percussionists (1979) was completely composed using "Project 1." In the 1980s, Laske wrote music for tape as well as instrumental and vocal compositions, whereby "Project 1" was the synthetic program for all compositions. An "electronic turn" came about with Furies and Voices for loudspeakers (1989-90) – for which he used PODX (granular synthesis) –, since melodic-rhythmic configurations of the 1980s tape compositions were replaced by a focus on density and sound color. This development continued in the 1990s, in which compositions for tape dominate, which are based on his own poetry: for instance, Treelink (1992) or Twin Sister (1995; disowned by him). Here, for the first time, Laske composed with the help of Kyma, an icon-based orchestra language for designing digital 'instruments' and entire 'orchestras' able to read numerical scores that function as the syntactic basis of a sounding composition. Other important compositions that followed were the Third String Quartet (1992-96), his Organ Piece (1998-99), Trilogy for tape (Echo des Himmels, Erwachen, Ganymed; 1999-2001), and his Symphony No. 2 (2003-2004).

Laske's instrumental works often show differentiated "soundcolor-counterpoint," which is also effective with vocal parts, while a-cappella works frequently show harmonic experiments. In tape compositions of the 1970s and 1990s, a primary interest in sound is dominating, while the tape compositions of the 1980s are rather contrapuntal. For Laske, music is primarily a lyrical expression, to which epic and dramatic elements are subordinate. His music is, it its variety, a personal expression via new, technical means. It strives for expression through constructions that are created rich of relations to sound and meter.

Otto Laske discovered a substantial change within composers who work with computers: a change from model-based to rule-based thinking, despite the motivation within the developmental tendency of musical thinking to return to model-based thinking. (See Laske 1989d, 3.) While in traditional compositional practice, existing music is the basis – the model – of composing, there is a new category – besides "existing music" – in composing with computers: "possible music". The latter is music "that can be envisioned by a musical expert on the basis of an abstract set of rules, on which a computer program is based" (ibid.). These abstract sets of rules may, hereby, lead to new musical forms and means of expression.

Laske distinguishes three ways of composing with computers: score synthesis, sound synthesis, and musique concrete. (See Laske 1994.) While in score synthesis, the computer generates score data – such as pitch, duration, dynamics, etc. – for use both in instrumental and tape composition, in sound synthesis computer software executes composer-designed electronic "instruments" grouped in "orchestras" to produce actual sound. By contrast, in musique concrete electronic transformers including synthesizers provide mechanisms for transforming environmental and/or speech sounds into novel sound sequences. Importantly, using computers in composition does not entail handing compositional control over to them. Rather, whether the composer uses computers as score- or sound generators, s/he is led to an intense "Aushören" (A. Berg), a process of internal (dialogical) listening in which the composer interprets numerical score data for the sake of shaping a specific composition. Laske became a pioneer in computer composition largely due to the fact that he used numerical ('digital') data produced by a computer program both for translation into traditional instrument notation (as G. M. Koenig had done) and for the sake of feeding input to an electronic orchestra language (such as Kyma) that is able to read such data.

Thus, Laske uses score synthesis for notated music as well as for tape compositions that are based on sound synthesis (rather than mere sound transformations). Hereby, the most important step is the process of interpreting numerical data, potentially even the same data for different compositional purposes or sets of acoustic or electronic instruments. Laske's main compositional toolset remained G. M. Koenig's "Project 1" program, which uses an abstract, composer-designed "structure formula" to create score data. Since score-based music is a special kind of music within the electronic realm, it is nowadays often called "score-based sampling" (a terms taken from sound synthesis) and associated with Laske's name.

Almost all of Laske's instrumental and vocal works composed after 1971, as well as his tape compositions of the 1980s, are based on "top down score synthesis" using Koenig's "Project 1". Despite the sameness of the tool set used, the compositional processes employed in acoustic and electro-acoustic works are starkly different, given that the listening required for the two media is entirely different, both for the composer and the audience. Laske's compositions between 1999 and 2009 are equally based on "Project 1", except that their sonic character is greatly influenced by his new emphasis on symphonic sound for which the technical means were not available in the 1980s or 1990s. Laske's compositions are, to equal portions, music for loudspeakers and instrumental chamber music (including music for solo instruments). Several pieces for loudspeaker set his own poetry to music; he does not use lyrics by other poets for his electronic compositions. In addition, there are numerous pieces for solo voice and chamber ensemble or music a cappella, of which six are based on his own poetry.

For Otto Laske, composing is closely related to his scholarly activities: "But I'm not interested in programs or machines that turn out compositions. Rather, what has always interested me are machine that allow and invite reflection about the compositional process and that simultaneously lead to a compositional product." (Laske, quoted in Schüler 1999, 149.) In this sense, Laske's artistic activity is a part of his scholarly research. However, since 1990 the emphasis on theoretical aspects of computer programs decreased in favor of their use as the basis for compositional thinking.

Otto Laske's Visual Music Animations

All of Laske's visual art and compositions, and some of his poetry, show the interrelationship between himself and "the computer as the artist's alter ego" (Laske 1990). In his artistic late-work, Laske transferred his experiences in shaping artistic materials in poetry and music to visual arts. (See Laske 2016a.) Throughout his career, Laske always saw new technologies as a gateway for new art. And so in 2009, Laske started a series of three visual music animations "to discover that animation stills are a potent source of both digital photography and digital painting. In light of the importance of music in my life, all of my visual work is 'frozen music' showing the inner dynamics of shape, color, texture, and line." (Ibid.) Among Laske's visual art, his visual music animations most closely represent his focus on artistic processes. Not only is he crossing painting, drawing, photography, collage, and animation, but the animation processes are in the center of visualizing Laske's computer music, because all of his visual music animations are based on his own electronic music as well as his own poetry. The musical syntax dictates the animation processes, and the colors are a visualization of the orchestration and, thus, sound colors. Sequences of images outline the musical form (which is ultimately rooted in score- and sound synthesis). In Laske's visual music animations that use poetry, however, the poetic meaning dominates and dictates images and sound (just like the lyrics dictate the sound in Laske's compositions with lyrics); in those lyrics-based visualizations, the images interpret the poetry. (Ibid.) Generally speaking, however, the traditional artistic genres are so fluidly married with each other that Laske's visual music animations can and should be seen as a new artistic genre itself.

Each of the three visual music animations shall be briefly discussed here. As his first animation, Coves was completed in 2011 and based on parts of Laske's 2009 electronic music "Being and Nothingness", the title of which refers to Satre's existentialist philosophy. The title of Coves, which can be viewed at https://vimeo.com/29217893, refers to pictures Laske took of several Cape Ann coves near Gloucester, MA, where Laske has been residing since 2010. These pictures were taken at Lanesville, Pigeon Cove, and Halibut Point (the most northern part of Cape Ann) in Massachusetts. A cove is a small type of bay or coastal inlet, often with narrow entrances and oval in shape. Dedicated to Dennis H. Miller (a composer-turned-animator who pioneered score-based videos and served as Laske's mentor), Laske's Coves reflects on the storms that helped shaping coves as well as the land's dependency on the sea, with both its threats as well as potentials (Laske 2016b). Synthesized, stark, melodic elements represent Nothingness, which provokes self-realization, or Being. Laske produced the music with "Project 1" (for the score) as well as Kyma's Capybara sound engine (for the sound). The first part of the 3-part, 8-minute visual music animation Coves represents moving forces that gradually overlay and move against each other. The second part "highlights the internal conflict of these moving forces, physical and psychological" (Laske 2011), while the third part continues the conflict, but calms down toward the end. Visually, sea landscapes are overlayed with rocks, waves, and the moving sky throughout Coves, set to a variety of sound mixtures.

Laske's 14-minute visual music animation TreeLink from 2012 (which can be viewed at https://vimeo.com/46947568) is based on Laske's reading of his own poetry with the same title, written in 1979, and on his electronic composition TreeLink from 1992. The lyrics are as follows (Laske 2016b):

> Evening light is weighing down
> on the playground oaks and maples
> early this wintry day.
>
> Here, in the snow-soft meadow,
> I have stood before, happier,
> not noticing the weight
> in the trees, when the sun sank
> to close the afternoon.
>
> The trees have aged.
>
> I suddenly know
> they were always aching
> under the heavy light.
>
> Afternoon hides below the grass,
> a raven descends, and the wind
> takes years off the branches,
> shifting them to my shoulders.
>
> I return weighed down,
> more certain,
> more luminous.

In his electronic composition TreeLink, text- / language-fragments are embodied by sounds, partially synthesized (via Capybara and its Kyma language) and partially based on the (modified) sounds of the reading itself. TreeLink addresses the topic of aging in five parts. Laske states about his used of his collages: “My use of collages in this animation is intentionally ‘painterly’. The movement of the images is closely allied with the flow of sound energy, and it is this alignment that, for me, is a must in ‘visual music’.” (Laske 2016b.) Trees play a central role in the imagery, as the poetry refers to a wooded area near Laske’s former residence in Needham, Massachusetts.

Dedicated to Laske’s wife Nadine Boughton, Farewell to Los Angeles (2012), which can be viewed at https://vimeo.com/37404596, is based on Laske’s (own) reading of the poetry with the same title, written in 1979. (The relatively lengthy poetry can be found at Laske’s website at http://ottolaske.com/animations.html.) The poetry centers around love and departure. The music used was taken from several of Laske’s electronic music compositions: “Message to the Messiah”, “In Memory”, and “Trilogy” (Erwachen and Ganymed). “Message to the Messiah” (1978), which was composed at the Electronic Studio of the University of Illinois, was the first piece in the Needham Series and is Laske’s only ‘synthesizer music’: based on a recorded improvisation on a Buchla Synthesizer with naturesque imagery (especially of the sea and of birds). “Memory” from 1988 is the fifth piece in Laske’s Needham Series, which was composed to celebrate his mother’s life. Originally a traditional score, composed with predefined progression rules, “Memory” was orchestrated with the polyphonic digital synthesizer DMX-1000. Last but not least, Laske used two pieces from “Trilogie” (2001), Erwachen and Ganymed, in which tone colors / sonic qualities are the central focus. Among all three of Laske’s visual music animations, Farewell to Los Angeles contains the clearest form of poetry reading and imagery. As “video poetry”, the collages of both realistic and abstract images follow, with their dialectical movements, the stanzas of the poem, supported by the structure of the music, to bring out the poetry in its fullest, like a “Gesamtkunstwerk”.

For all of Laske’s animations, individual frames became the ‘negatives’, on which he bases his work in the visual arts. This art is musically inspired throughout, with a focus on flow, tension, conflict, and movement. In his visualizations, animation ‘objects’ carry visual images or even a sequence of images, and while the images move against and through each other, their colors, shapes, and textures follow the flow of the music. Laske treats an animation still as the visualization of a set of pixel-level parameters that define the shapes, colors, textures, and dynamic characteristics of an image. Working with Cinema 4D, Studio Artist, and Photoshop, Laske’s work is highly creative.

Final Remarks

Laske’s visual music animations best represent his entire artistic and scholarly work. Musical competence and performance (activity) as well as musical artifacts are to be examined in their polarity, which means that the examination of musical artifacts has to occur not only in themselves, but also with regards to its underlying competence and performance (manifest in real-time compositional processes). Music is a series of tasks, of which cognitive structure and processes are to be explored. To have developed such a methodology is the result of Laske’s research in linguistics, but especially in psychology, computer science, and Artificial Intelligence. Music is understood as a cognitive achievement, which requires – in order to understand it – a structural as well as procedural analysis of tasks. Thus, dialectical thinking (Laske 2012 and 2017) with its distinction between ‘structure’ and ‘process’ as well as the emphasis on work in real time are central categories in Laske’s work, and his visual music animations exemplify them in the artistically broadest way.

References

Laske, Otto. (1971a). *On Problems of a Performance Model for Music*. Utrecht, The Netherlands: Institute of Sonology.

Laske, Otto. (1971b). An Acoulogical Performance Model for Music, In *Electronic Music Reports 4* (September): 31-64.

Laske, Otto. (1074). Musical Acoustics (Sonology): A Questionable Science Reconsidered, In *Numus West 6*: 35-40.

Laske, Otto. (1975). Towards a Theory of Musical Cognition, In *Interface 4*/2: 147-208.

Laske, Otto. (1977). *Music, Memory and Thought: Explorations in Cognitive Musicology*. Ann Arbor: UMI.

Laske, Otto. (1986). Toward a Computational Theory of Musical Listening, In *Communication and Cognition 18*/4: 363-392.

Laske, Otto. (1989a). Introduction to Cognitive Musicology, In *The Journal of Musicological Research 9*/1: 1-22.

Laske, Otto. (1989b). Composition Theory in Koenig's Project One and Project Two, In Roads, C. [Ed.], *The Music Machine: Selected Readings from 'Computer Music Journal'*: pp. 119-130. Cambridge, MA: The MIT Press.

Laske, Otto. (1989c). Composition Theory: An Enrichment of Music Theory, In *Interface 18*/1-2: 45-59.

Laske, Otto. (1989d). Die Integration neuer Technologien in die Denkweisen des Musikers. Unpublished Manuscript.

Laske, O. (1990). The Computer as the Artist's Alter Ego, In *Leonardo 23*/1 (Winter): 53-66.

Laske, Otto. (1993a). A Search for a Theory of Musicality, In *Languages of Design 1*: 209-228.

Laske, Otto. (1993b). An Epistemic Approach to Musicology, In Haus, G. (Ed.), *Music Processing*: 109-118. Madison, WI: A-R Editions.

Laske, Otto. (1993c). Mindware and Software: Can they Meet?. In *Proceedings of the International Workshop on Knowledge Technology in the Arts*: 1-18. Osaka 1993.

Laske, Otto. (1994). Sieben Antworten auf sieben Fragen von N. Schüler. Unpublished Manuscript.

Laske, Otto. (2004). *Musikalische Grammatik und Musikalisches Problemlösen: Utrechter Schriften (1970-1974)*, ed. by Nico Schüler. Frankfurt / Main: Peter Lang.

Laske, Otto. (2011). Cove Program Notes. Manuscript.

Laske, Otto. (2012). Living Through Four Eras of Cognitive Development, In *Integral Leadership Review*. http://integralleadershipreview.com/7499-living-through-four-eras-of-cognitive-development/

Laske, Otto. (2016a). Artist Statement. Last accessed on September 12, 2020. http://www.ottolaske.com/gallery.html

Laske, Otto. (2016b). Animations. Last accessed on September 12, 2020. http://ottolaske.com/animations.html

Laske, Otto. (2017). A New Approach to Dialog: Teaching the Dialectical Thought Form Framework. https://interdevelopmentals.org/wp-content/uploads/2020/02/2017b-Introduction-to-DTF.pdf

Miller, George A. (1960). *Plans and the Structure of Behavior*. New York: Holt.

Schaeffer, Pierre. (1966). *Traité des Objets Musicaux*. Paris: Seuil.

Schüler, Nico. (1995). *Erkenntnistheorie, Musikwissenschaft, Künstliche Intelligenz und der Prozeß: Ein Gespräch mit Otto Laske*. Peenemünde: Dietrich.

Schüler, Nico. (1997). Otto Laske, In Heister, H.-W, and Sparrer, W.-W. (Eds.). *Komponisten der Gegenwart*: 1-2. München: edition text+kritik, 11. Nachlieferung.

Schüler, Nico. (1999). A Composer's Cognitive Musicology, In Tabor, J. (Ed.). *Otto Laske: Navigating New Musical Horizons*: 136-150. Westport, CT: Greenwood Press.

Schüler, Nico. 2003. "Otto E. Laske," In Finscher, L. [Ed.] *Die Musik in Geschichte und Gegenwart*, Personenteil vol. 10: 1235-1237. Kassel: Bärenreiter.

Tabor, Jerry [Ed.]. (1999). *Otto Laske: Navigating New Musical Horizons*, Westport, CT: Greenwood Press.

[Abstract in Korean | 국문 요약]

오토 라스케와 전자음향음악의 시각화: 라스케의 시각적인 음악 애니메이션

니코 쉴러

컴퓨터 음악의 선구자이자 (음악학, 철학, 컴퓨터공학, 심리학, 언어학, 기호학, 사회학의 원리에 뿌리를 두고 있는) "인지 음악학"의 창시자인 오토 라스케Otto Laske (1936년생)는 자신의 연구를, 처음에는 작곡과 작시, 나중에는 디지털 아트까지의 예술적 활동과 결부시켰다. 이 글은 라스케의 1966-2009년 시기 전자음향음악과 2011-2012년 전자음악의 시각화에서 이룬 예술적 성과를 담고 있는 그의 이론 중 몇몇 전기적이자 예술적, 연구적 배경을 제공한다. 이러한 애니메이션에서, 그는 각 개별 프레임을 원판으로서 시각예술 작품의 근거로 삼았다. 이는 흐름과 긴장, 갈등, 움직임을 중심으로 작품 전체에서 음악적 동기가 부여된 예술이다. 그의 시각화 작품은, 애니메이션 '대상objects'이 시각 이미지나 연속되는 이미지도 전달하며, 이미지들이 서로 맞붙거나 지나치면서 음악의 흐름에 따라 색과 모양, 질감을 바꾸기도 한다. 라스케는 에니메이션 이미지를, 이미지의 모양과 색상, 재질, 움직임의 특징을 결정짓는 각 요소(파라미터) 픽셀들의 집합체가 시각화한 것으로 취급한다. 시네마 포디Cinema 4D, 스튜디오 아티스트Studio Artist, 포토샵Photoshop으로 일하는 라스케의 작업은 꽤 창의적이다. 라스케의 시각화 작품 중 몇몇은 그의 필생사업으로서 연구되며 전체적으로 주시받고 있다.

주제어: 오토 라스케, 전자음향음악, 시각화, 시각 예술.

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PART II: Reviews

제2부: 참관기

전자음악의 외침:
2020 서울국제컴퓨터음악제 참관기

임진형
피아니스트 겸 음악학자

한국전자음악협회 KEAMS 는 2020년 10월 28일부터 31일까지 예술의 전당 '자유소극장'에서 제27회 서울국제컴퓨터음악제 SICMF를 개최했다. 여기엔 젊은 작곡가들의 경연 "페스트-엠fest-m", 일련의 콘서트, 컨퍼런스가 포함된다. 피아니스트이자 음악학자로서 나는 현대 작곡가들의 작품을 연주하며 음반 제작을 꾸준히 실행해 왔지만, 이렇게 전자음악만을 집중적으로 접할 기회는 정말이지 없었던 것 같다. 하여 내겐 아주 강렬하고 흥분되는 경험이었다. 연주자라는 나의 배경 때문일까, 리뷰를 위한 (여섯 개의) 작품들을 선정하고 보니 연주자와 전자음악이 함께 어울리는 곡들이 대부분이었다.

Exploring Electro-Acoustic Music:
Seoul International Computer Music Festival 2020 Review

Jin Hyung Lim
Pianist and Musicologist

From October 28 to 31, 2020, the Korea Electro-Acoustic Music Society (KEAMS) hosted the 27th Seoul International Computer Music Festival (SICMF) at Jayu Theater, Seoul Arts Center. SICMF includes a young composers' competition "fest-m," a series of concerts, and conferences. As a pianist and musicologist, I have often performed and made recordings working with contemporary composers, yet I haven't really had the chance to explore electroacoustic music. It was an intensive and exciting experience. On the basis of my performance background, I have chosen to review six works most of which involve performers.

Sujin Kim "Circular Point line and plane" for 4-channel live-audiovisual projection

The festival opened with the "fest-m" competition presenting talented young composers and their works. I particularly enjoyed Sujin Kim's 4-channel live-audiovisual piece *Circular Point line and plane*.

The first half establishes the characteristics and possibilities of a sine tone. On a black screen, first we see molecules gently orbiting a black center—a gentle start. There is a sense of burgeoning, pushing. Then the softness of drones combines with the pointillistic angularity of hyper-fast repetition, alongside numerous familiar effects and tricks (echo, reverb, etc.), building a heterophony. The film introduces a white/empty space on which a single black line is explored, first in angular lines, then, after the energy picks up, by exploring beating between clashing sine waves. This empty space creates and stimulates the power of the imagination to send invisible/inaudible(?) resonances to receivers. Then, the screen goes black: frenetic flashes of white lines streak across the screen, followed by vertical collections like refracted sound waves. The black on white is reminiscent of Viking Eggeling's *Symphonie diagonale* (1923). In the second part, the piece calms down and settles into a spectral space: a deep fundamental bass tone with whistling overtones and a more reflective, (spectral) harmony driven space defined by sustain and gradual shifting. Visually, disparate circles gradually emerge—akin to looking at bacteria through a microscope—which then tessellate to form a single nucleus, merging their whiteness, all fading in the end. This section feels more purposeful, considered, and selected—a natural complement to the multiplicity of the first half.

This piece reminds me of South Korean philosopher and artist Lee Ufan's structured paintings *From Point From Line From Wind* in its unending process, with the repetition of appearing and disappearing suggesting infinity, as well as in its dynamic relationship between what was marked (positive object) and what was not (negative space). For this reason, the film itself to me created a sort of vibration. The work is well-paced and is matched well by the intensity between the sonic experience and the visual presentation.

Monte Taylor "Sigil II: Amistad" for saxophone and 8-channel live electronics
Saxophone: Yeomin Yoon

As the composer explains about the piece in the program note, in "navigating various computer-generated soundscapes, the saxophone struggles to maintain its identity amongst the chaos of many competing spectra." In a piece like this, we, as listeners, look for a sense of the live instrument's initial identity and its progression; however, as this was not clear enough, I was unable to hear its "struggles" and eventual "dissolution." In the first moments there is already a lot going on, or there is not enough of a definitive identity to follow: single staccato notes; multiphonics; huge staccato leaps in tessitura (a very recognizable gesture that does not return); descending chromatic scales; trills (sometimes multiphonics?); humorous jazz-styled moments, physically illustrated by the performer; riffing around a minor ninth. Halfway through the piece, breath noises and key clicks are also introduced. Despite some moments of definitive repetition—sequential rising scales in a normal timbre—all this live sonic material is insufficiently developed or punctuated to provide a cohesive rhetoric to indicate the structure. Thus, I feel lost in the piece—like the saxophone presumably. Are all these sounds meant to represent "multiculturalism"? The piece captures a certain volatility and frenetic energy at times but seems to lack clear structural punctuation more broadly, especially as the saxophone's many sonic materials are frequently heavily fragmented, separated by silences.

From the start, the volume of the electronics gradually increases, immersing the saxophone (playing ascending scales, higher and higher), then it calms and quiets down when the second half starts. At this point there is heavier electronic treatment of the saxophone, which plays a long line that unfurls surrounded by drones: the line distorted in live reflections. Later, it moves into the somewhat tonal space of broken chord material. It is then unclear how the saxophone "dissolves" into the collected spectra, as the live saxophone is still foregrounded texturally and by timbre (at least in the overall balance). Moreover, the saxophone still instigates the electronics processing its sound. "Amistad" means "friendship"—the heavily ironic name of an infamous slave ship. Although saxophone and electronics seem friends by the end, the piece ends somewhat abruptly with a swift fade-out, feeling unfinished. It feels too long as a whole.

Soonyoung Park "Go!" for clarinet and 2-channel live electronics
Clarinet: GeonJoo Kim

The clarinet does brilliance well, which is used to very satisfying effect in this piece. The piece opens with a bright, broad unison: deep bass octave harmonization beneath the clarinet's chalumeau. There is a compelling polyphonic sense (à la Bach's solo suites), switching between imposing rising octaves and high-register florid gestures, diminished seventh runs, and stacking motivic/melodic sequences to build tension. The clarinet is electronically treated with some reverb and delay.

In this work, the drum is introduced to create high drama. Drum sounds continue and develop, while the clarinet's timbre opens out with more live-electronic harmonies: bright thirds dance and intervals are more discordant, building a high, triumphant, majestic sound. The work was originally written for the violin and, curiously, you can hear how the piece would work well for its original instrument in the way the delay/echo effect captures energetic, rapidly rising gestures.

What attracted me the most about this piece was the relationship between the clarinet and the drum. Drawing upon my cultural identity of "Koreanness," this piece appears to be reminiscent of the traditional Korean musical genre *Pansori*, which was declared a UNESCO Masterpiece of the Oral and Intangible Heritage of Humanity in 2013. *Pansori* originated during the Joseon dynasty (1674–1720) and became fashionable from the eighteenth century onward. It is a form of musical storytelling, often referred to as Korean solo opera, which requires one *sorikkun* (a voice) and one *gosu* (a drummer). A vocalist alternates a spoken narrative with a sung section. The *changgo*, the most common type of drum in Korea, is used to accompany the singer. Thus, *pansori* is the basis for vocalization in dramatic storytelling, and is a speaking melody for a solo voice and an accompaniment. This combination of speaking and singing makes *pansori* similar to the genre of melodrama that inspired Schoenberg's *Sprechgesang* in works such as *Pierrot Lunaire*, op. 21 (1921). Returning to Park's piece, the clarinet takes the role of the *sorikkun* with its operatic combination of speaking and singing effects, while the drum adds "heung" (the composer's expression of joy) to the piece with its rhythmic supports.

The piece has great electronic orchestration and pacing and the performance was very strong and committed. It is a short and enjoyable piece that would make an excellent concert opener anywhere!

Taehi Kim "Breath" for clarinet and 9-channel live electronics
Clarinet: GeonJoo Kim

The clarinet begins with a single breath in a slow quiet opening. A melodic line unfolds, interspersed with a series of long exhalations, rising up. A sudden electronic breath sound is an effective, abrasive interruption. Breath then remains in the piece as another character (rather than as an antagonistic timbre as this would suggest). The melodic line enters the loneliness of the clarinet's higher register (the clarion) and develops. A staccato repeated note (double-tongued) motif is introduced lower in the chalumeau, which triggers the electronics to start adding reverb and delay. The staccatos move into the altissimo around the melodic material. The exploration of the staccato idea builds a sense of conflict, which is interspersed with softer, more fragile multiphonics.

Then, there is a break: a new section explores the repeated note motif, now legato and smooth, as part of a melodic line with electronic harmonization. The mood is melancholic; breath is still present. Returning to the deep end of the chalumeau, the live clarinet is surrounded by breath sounds, seeming both comforting and cautionary—an uneasy unison.

This is a great and very moving work, again performed compellingly by GeonJoo Kim. It has good pacing, and uses materials effectively and economically. It is rather a "statement" piece: a poetic response to Covid-19 capturing an intimately individual perspective of the pandemic: of the fear, grief, and hope for positive unity.

Jorge García del Valle Méndez "Ten Steps" for piano and 2-channel live electronics
Piano: Eun-young Son

Electronics set the space in this piece, opening with echoes of traditional Korean music. From its deep bass register, the piano emerges. Thereafter, the piano materials come only from the electronics, and always lead back to them, which are foregrounded in the mix. The piano is sometimes fully submerged or immersed in the electronic sound. As a pianist-listener, I was a bit uncomfortable whenever I couldn't really catch the pianist Son's rhetorical expressions under the overwhelming electronic sounds (whether it was meant to be or not).

The pitch intervallic material combines semitonal movement with fourths and fifths. A punchy, single staccato note motif encapsulates the anguished tension and volatility that seems to form the centre of the piece. Using a polyphonic instrument such as the piano in this way makes it interesting to compare this particular motif with the pieces for solo woodwind. Echoes of "Arirang" and a distant voice sometimes emerge in the electronics, notably as screams at around 3'00" and later drifting past as dream-like, reverb-heavy moments.

The piece successfully blends fixed pitch and noise material through live treatment of the piano, at times slight and at others heavy. It is a satisfying and exact performance.

Joong-Hoon Kang "A Summer Day" for piano and 2-channel live electronics
Piano: InKyung Hong

> *The green leaves, the sounds of insects, the hot and humid breeze around my body, and the rain pouring violently. . . . With piano and computer-generated sound, I depicted the scenery of a summer day came into my eyes as if time stopped.* (Program note)

This is a lovely, very approachable piece with an ABA structure. The A section features soft, motivic melodic writing in a sparse texture. Repeated figures blend open fifth harmonies with gentle chromaticism, each gesture resonating. Gradually, soft electronic sounds emerge sustaining the resonance.

A spread chord motif bookends the B section presenting "rain pouring violently." From a sonorous bass chord, the pianist creates cascades running up and down exploring open fifth broken chords moving stepwise. The atmosphere is vibrant but tense. I found it harder to hear the electronics in this section due to a lot of pedal and accumulating resonance. Perhaps the composer insists that the electronics play the role of the piano's shadow.

The cascades calm and the piece returns to the A section. This time, high chimes are added in the electronics (to me, reminiscent of the Japanese *shō*) to accompany the highest pitches.

It is arguably straightforwardly sentimental, but it is satisfying in its simplicity—the most economical of these six pieces—and sensitively performed.

Standing at the Crossing Point of Virtual and Real: Review of *LINK (Yeon II)* Performance

Park, Hayoung
NMARA Curator, New Media Art Project Manager.

NMARA's *LINK (Yeon),* premiered in 2019 as an interdisciplinary art performance project, was followed by *LINK (Yeon II)* presenting the connection between the virtual and the real through "water" as a medium in 2020. *LINK (Yeon II)* was featured by directing the audience to feel 3D visual and audial information, with combining the use of techniques to emphasize the theme of the connection between the virtual and the real and the way of artistic expression considered as relatively universal methods. Coexistence of digital and live acoustic sounds through the multi-channel sound system, the extended 3D-screen projections with dynamic projection mapping, and VR performances based on WebXR and 3D VR video streaming service are such examples. Now the demands for artistic activities in an untact environment gets significantly higher, the questions have been raised: how art would develop and evolve at this time, how the immersive experience could be intensified in practice, and in what capacity art serve as a medium in standing at the crossing point of virtual and real.

가상과 실재의 교차지점에 서서: LINK (緣二) 시연회 참관기

박하영
NMARA 큐레이터, 뉴미디어아트프로젝트 매니저

2019년 초연한 NMARA의 다원예술공연 프로젝트 link (緣)의 두 번째 이야기, 다원예술공연 LINK (緣二)는 '물'이라는 매개체를 통해 가상과 실재의 연결을 이야기하고 있다. LINK (緣二)는 가상과 실재의 연결이라는 주제를 드러내기 위해 작품에 사용된 기술과 보다 보편적이라고 여겨지는 예술의 표현방식을 적극적으로 융합하여 관객으로 하여금 입체적인 시각정보와 청각정보를 느낄 수 있게 연출한 것이 특징이다. Multi-Channel Sound System을 이용한 디지털 사운드(Digital sound)와 라이브 사운드(Live sound)의 공존, 3면 프로젝션에서 Dynamic Projection Mapping으로 확장한 스크린, WebXR과 3D VR 영상 스트리밍 기술로 제작한 VR 공연이 그 예다. 비대면 예술환경의 중요도가 어느 때보다 높아진 지금 이 시대의 예술은 어떻게 진화하고 발전해야 할지, 공연에서의 몰입 경험은 어떻게 발달해야 할지, 가상과 실재의 교차지점에서 예술은 어떤 매개체가 될 수 있을지 함께 물음을 던져보고자 한다.

다원예술공연 링크 (연이)LINK (緣二)는 2019 년 초연한 엔마라 NMARA 의 다원예술공연 프로젝트 링크 (연)link (緣)의 두 번째 이야기이다. <緣>의 주제를 이루는 줄기에는 '연결'이 있다. 첫 번째 작품인 link (緣)는 사람과 사람 사이의 연결, 인간과 인공물(AI)의 공존, 예술 장르 간의 융합을 인드라망이라는 소재에서 출발해 메시지를 전했다면, 두 번째 작품 LINK (緣二)는 가상과 실재의 연결을 이야기하고 있다. LINK (緣二)에서는 가상과 실재의 연결이라는 주제에 맞게 몇 가지 연출적인 시도를 엿볼 수 있다.

디지털 사운드 Digital sound 와 라이브 사운드 Live sound 의 공존은 LINK (緣二)의 가장 특징적인 장면 scene 을 구성한다. 공연은 암전 상태에서 시작한다. 8.1 채널로 구성된 다채널 사운드시스템 Multi-Channel Sound System 은 여덟 개의 스피커와 하나의 서브우퍼로 이루어져 관객을 전 방향에서 둘러싼다. 공연이 시작되면 타악기를 소재로 한 전자음악 사운드는 여러 개의 스피커에 흩어져 관객 주위를 사방팔방 맴돌며 불규칙하게 재생되다 하나의 덩어리가 되어 가운데로 모이고, 이때 무대 한가운데서 고수는 조명과 미디어아트 영상과 함께 '쿵'하고 북소리를 내며 등장한다. 이는 소리 객체의 다양한 이동과 실감 나는 입체적 공간감을 느낄 수 있는 LINK (緣二)의 인트로 Intro, 천지창조 Scene 이다. 고수는 계속해서 북을 연주한다. 무대를 감싼 3 면 프로젝션 스크린에 재생되는 미디어아트 영상에는 마치 고수의 북소리에 맞추어 물결이 만들어지는 것을 표현하듯 물방울이 율동감 있게 튀어 오른다. 북소리는 점점 고조되며 전자음향과 혼재하며 신비감을 더한다.

LINK (緣二)에서 '물'은 작품 전체를 아우르는 키워드이자 가상과 현실의 교차지점에서 매개체가 된다. 그래서 물은 공연 내내 다채로운 모습으로 등장하여 표현된다. 2 막 레테의 강에서 표현된 물은 3 가지 형태로 압축해 볼 수 있다. 먼저 3 면으로 제작된 스크린은 공간에 입체감을 주어 관객에게 몰입감을 선사하는 장치가 된다. 3 면 프로젝션으로 펼쳐지는 물 이미지는 작은 물결로 시작해 큰 파도가 되어 일렁이는데 그렇게 표현된 압도적인 검은 파도는 마치 심연에 빠진 듯한 인상을 주어 관객의 신화적 상상력을 자극한다. 3 면 프로젝션의 물은 두 번째, 천 위의 역동적인 프로젝션 매핑 Dynamic Projection Mapping 으로 확장된다. Dynamic Projection Mapping 은 공연자의 실루엣을 실시간으로 자동 추적해 사용자 실루엣 영역에 미디어 작품을 동적으로 프로젝션 맵핑하는 기술이다. 2 막 '레테의 강'에서는 각각 망각의 여신 '레테,' 고통의 여신 '알게아,' 미망의 여신 '아테'가 되어 등장하는 3 명의 퍼포머를 추적해 물로 묘사한 5m 천의 실루엣 영역에 파도 이미지를 투사한다. 퍼포머는 몸과 천의 움직임을 이용한 퍼포먼스를 선보이고, 관객은 눈앞에 실재하는 천이 무용수와 함께 물결치듯 춤추는 것을 보며 무대에 여러 층의 파도가 존재한다고 인식하게 된다. 마지막으로 다채널 사운드 시스템 Multi-Channel Sound System 장점을 살려 여러 층으로 흐르는 물소리 역시 다양한 소리를 겹쳐 사용해 실감 나는 소리를 경험할 수 있었다. LINK (緣二)는 가상과 실재의 연결이라는 주제를 구현하는 데 있어 작품에 사용된 기술과 보다 보편적이라고 여겨지는 예술의 표현방식을 적극적으로 융합하여 관객으로 하여금 입체적인 시각정보와 청각정보를 느낄 수 있게 하였다.

LINK (緣二)가 가지는 다른 공연과의 차별점은 가상현실 VR 공연에 있다. 작품의 맥락 안에서 주인공은 전생의 문을 통과해 자신의 수많은 전생을 마주하게 되는데, 이는 라이브 공연에서도 묘사가 되었지만 VR 공연을 통해 보다 적극적으로 구현되었다. LINK (緣二)의 VR 공연은 4 개의 플랫폼에서 즐길 수 있도록 준비되었다. 가상 공연장은 기본적으로 가장증강현실 WebXR 환경으로 구현되어 별도의 앱 설치 없이 웹 url 주소로 접근하여 VR 공연을 감상할 수 있고, 시연 장소에서는 가상현실헤드셋 VIVE 과 노트북 브라우저, 모바일 폰을 이용해 체험해볼 수 있었다. VR 과 예술의 만남을 생각하면 VR 기술로 만들어진 플랫폼 안에 콘텐츠로서 예술이 들어간 형태를 떠올리기 쉽지만 LINK (緣二)의 VR 공연은 예술을 확장하는 표현적 도구로서 VR 기술을 이용해 작품의 완성도를 높였다. 동물들의 환생을 표현한 scene 은 낮은 시점에서 촬영해서 공연을 체험하는 관객이 마치 무대 위에 함께 존재하고 상호작용한다는 느낌을 받을 수 있도록 연출한 것이 그 예이다. 다만 Web 기반인 WebXR 구동 환경의 한계로 초고화질 영상 스트리밍이 현재 기술로는 구현이 어려워 2K 입체 360 영상을 제공한다. 초고화질인 8K 로 제작된 영상은 유튜브에 업로드되어 관객이 자신의 모바일 폰과 카드보드를 이용해 체험하거나 현장에 설치된 노트북을 통해 감상할 수 있었다.

다원예술공연 LINK (緣二)가 WebXR 과 유튜브를 이용해 VR 공연으로 제작된 것은 COVID-19 의 확산으로 국공립 박물관 및 미술관, 공연장이 대대적인 휴관을 시행함에 따라 온라인 플랫폼을 활용한 온라인 전시 및 공연, 온라인 예술 교육 등이 활성화되었고 우리나라뿐만 아니라 세계 곳곳에서 비대면 예술환경의 중요도가 높아지게 되었기 때문이다. 이는 4 차 산업혁명 시대를 살아가며 점점 높아지던 Art & Technology 에 대한 요구를 가속하는 계기가 되었다. 비대면 시대의 예술은 어떻게 진화하고 발전해야 할까, 공연에서의 몰입 경험은 어떻게 발달해야 할까, 예술이 가상과 현실의 교차지점에서 어떤 매개체가 될 수 있을까. 우리가 서 있는 이곳이 가상과 실재의 교차지점이 아닌지 물음을 던져본다.

Art Beyond Boundaries:
Review of *ELECTRONICA-IV*

Shim, Jiun
VD Production Media Div. Producer

ELECTRONICA-IV is the fourth project in a series that clarinetist Geonju Kim has presented every year, based on her researches with focus on the repertoire for clarinet and electroacoustic sound. This ELECTRONICA series has been persistently trying new attempts over the years; ELECTRONICA-I performed mainly audio-centered works, while the fourth showed a remarkably different stage. In the white-cube hall, video art works transforming in response to the player's sound, digital scores generated in real time, countless cable lines exposed unreservedly, and composers programming live on the stage demonstrated that there were no longer limit to express and no distinction between things to reveal and things to cover. The recitals for solo instrument in Korea typically had a unified and conventional style, which seems to get more diversified and more flexible by the attempts such as this series. The author reviews some characteristic points with six artworks featured in the fourth concert.

장르적 경계를 넘어선 시각예술:
ELECTRONICA-IV 참관기

심지운
VD 프로덕션 미디어 사업부 PD

ELECTRONICA-IV는 김건주 클라리네티스트가 클라리넷과 전자음향으로 이루어진 레파토리만을 연구하여 매 해 발표해 온 시리즈 중 네 번째 프로젝트이다. ELECTRONICA시리즈는 해를 거듭하며 꾸준히 새로운 시도를 선보였는데, ELECTRONICA-I 공연에서는 오디오 중심의 작품을 발표했었다면 네 번째는 현저히 다른 모습을 보여주었다. 화이트큐브[1] 홀에서, 연주자의 소리에 반응하여 형성되는 비디오아트, 실시간으로 만들어지는 전자악보, 가감없이 노출된 무수한 케이블 선, 그리고 작곡가들이 연주공간stage에서 직접 프로그래밍 하는 모습까지, 더 이상 표현에 제약을 걸지도, 드러낼 것과 숨길 것을 구분하지도 않았다. 일원화된 무대양식을 가지고 있었던 한국의 전형적인 독주악기 연주회는, 위 시리즈와 같은 시도를 통해 점차 다원화되고 유연해질 것으로 보인다. 필자는 네번째 시리즈에서 갖춰진 이와 같은 특징적 요소들과 여섯 개의 작품들을 리뷰하고자 한다.

본 연주회에서 큰 역할을 한 요소 중 하나는 공간이다. 현대의 음악 연주회들은 콘서트 홀을 벗어나 아트센터, 갤러리, 심지어 카페 앤 바에서도 열린다. 위 양상은 첫째, 음악을 더 이상 음질로 평가하지 않는 것과, 둘째, 연주회가 청각적 요소만 담고 있지 않음을 보여주는 지점에서 출발한다. 소리에 울림을 더해 줄 기능성 목재로 곡률을 살려 만든 벽 보다, 그 소리를 시각화하여 보여주기에 적합한 흰 벽이 더 효율적인 시대가 온 것이다. PLATFORM-L의 아트센터는 관람자의 인식에 영향을 주는 벽의 색과 구조를 전부 배제하고 말 그대로의 화이트 큐브를 형성했다. 물론 우수한 오디오 시스템으로 사운드 퀄리티 또한 놓치지 않았으며, 조명, 프로젝터 및 기타 무대장치도 완벽히 갖추고 있었다. 단 한가지, 언택트 시대에

필수적인 네트워크 시스템은 아직 개선이 필요해 보인다. 그 외 모든 공간적 구성요소는 연주자가 실험하기에 좋은 빈 캔버스와 같은 역할을 해주었다.

이번 공연은 중첩Superimposition이라는 부제로 진행되었는데, 총 여섯 개 곡의 의도와 흐름이 그 단어와 일맥상통하였다. 이는 포스터에도 드러나는데, 연주자의 얼굴이 이중노출기법으로 중첩되어 있었고, 두 모습이 서로 다른 분위기로 각각의 자아를 보여주고 있었다. 유태선 작곡가의 곡, 《Reflections of the Ego for Clarinet in B♭and Live Audio Visual Media》는 자아의 반영, 자아의 상, 즉 눈에 보이거나 마음에 그려지는 자아의 형체에 대한 내용을 담고 있었고, 현종찬 작곡가의 곡, 《Clarinet and Computer2》은 연주자와 컴퓨터가 만드는 일정하게 반복되는 비트beat로 부조화와 조화를 함께 그려낸 작품이었다. 오예민 작곡가의 《Sonic Diplopia》은 겹보임, 혹은 복시라는 현상을 표현한 작품인데, 이 현상은 하나의 물체가 두개 이상의 상으로 보이는 증상을 가리킨다. 임승혁 작곡가의 《짧아짐verkürzt IV for Clarinet》은 비디오 딜레이를 사용하여 녹음, 녹화된 곡이 다시 재생되며 중첩되는 모습을 보여준다. 조진옥 작곡가의 《LoopUp for Clarinet and Live-processing》은 기본이 되는 rhythmic 패턴, 즉 loop이 이 곡의 기본 골격을 이루는데, 컴퓨터와 클라리넷이 함께 소리를 켜켜이 쌓아 올리는 build up 과정을 보여준다. 이처럼 네번째 시리즈의 곡들은 이중적인 이미지를 지닌 채 흩어지고 다시 중첩되며 합쳐진다. 김건주는 연주 뿐이 아닌 전반적인 무대 기획에서도 이와 같은 특징을 살려 주체로서의 자아와 객체로서의 자아, 그리고 그 사이의 갈등에 대해 표현한다.

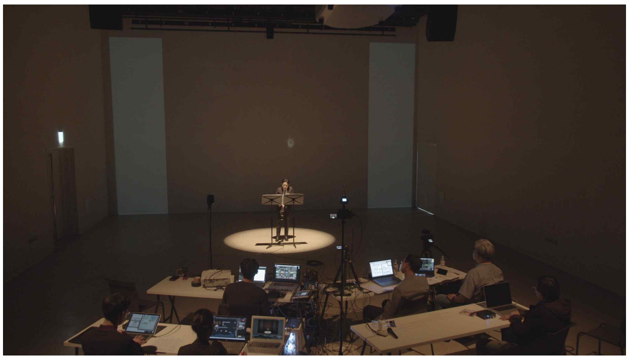

그림 1. 유태선의 《Reflections of the Ego for Clarinet in B♭and Live Audio Visual Media》(2020) 공연현장

그림 2. 안성희의 《The Last Colony for Clarinet in B♭ and Live audio-visual media》(2020) 공연현장

유태선, 《Reflections of the Ego for Clarinet in B♭and Live Audio Visual Media》(2020)

곡의 첫 도입부는 매우 느리게 진행이 되며, 모든 소리가 ppp<p 정도의 작은 소리만으로 이루어져 있다. 어두운 멀티포닉스의 소리가 전자음향과 어우러진다. 이로 인해 무거운 분위기가 지속되는데, 중간부는 초반부와는 대조되어 템포가 높아지고 리듬의 움직임도 빨라진다. 후반부에서는, 강한 슬랩텅들이 등장하다가 강력한 바람소리로 마무리된다. 프로그램 노트에 소개된 《나카자와 신이치의 예술인류학》의 내부시각(어두운 곳에 오래 있을 때 시신경의 진동으로 보여지는 희미한 빛)이라는 개념을 소재로 쓰여진 이 작품은, 자아 내면에 있는 여러 가지 감정들을 복합적으로 표현한 인상을 준다. 작곡가 유태선은 이를 다음과 같이 각색하였다. "어둠속인데도 눈 안쪽에서 호나한 빛이 쏟아져 나오는 내안 또는 내부시각 현상이 생긴다…오랜 옛날 사람은 어둠 속에서 자신의 내부를 들여다봤을 때 눈에 비친 것은 바로 이런 강하게 유동하는 마음의 적나라한 모습이 아니었을까? 사람은 이 마음의 본질을 들여다보고 일상적이 마음의 작용과는 전혀 다른 어떠한 초월적인 것이 자신들의 마음 내부에 있다는 것을 발견한 것은 아닐까?"

안성희, 《The Last Colony for Clarinet in B♭and Live Audio Visual Media》(2020)

이 곡은 청중으로 하여금 악화되고 있는 환경문제에 대한 위기의식을 느끼게 하는 작품이었다. 특징적인 무대 연출로는, 연주자를 암전시켰다가 연주가 나올 때에만 연주자에게 스팟 조명을 주어 사운드를 강조한다. 소리 중심 공연에서 나아가, 메시지를 적나라하게 드러내는 시각적 영상에 힘을 주기위한 의도로 보인다. 암전을 통해 관객들의 집중력과 상상력을 자극할 수 있는 환경을 만들어 주기도 한다. 인트로는 밝은 전자음향과 함께 영상이 재생되는데, 아름다운 지구와 파란

바다가 등장하며 곡의 서사를 시작한다. 클라리넷이 등장하기 직전, 전체 분위기는 어두워지며 전자음향소리와 화면 역시 흑백으로 변한다. 무언가를 암시하는 이야기가 시작되는 것을 느낄 수 있었다. 바다가 감당할 수 없는 양의 쓰레기들, 떠다니는 페트병 그리고 죽어가는 물고기와 새들이 관객에게 적나라한 메시지를 쏘아붙인다. 중반부 클라리넷은 매우 강한 소리와 빠르고 높은 음역의 멜로디를 섞어가며 분위기를 급하게 만들어 나간다. 이와 같은 클라리넷 사운드의 음악적 효과는 상승하는 지구의 온도와 악화된 환경의 위치를 음의 높이와 강도로 묘사하는 것으로 볼 수 있다. 후반부에서는 키클릭과 숨소리들이 등장하는데, 영상 속 지구가 점점 우리에게서 멀어져감과 동시에 전자음향 사운드 또한 점차 페이드 아웃된다. 엔딩은 인간이 영위하고 있는 지구의 삶이 끝나가고 있음을 표현하며 관객에게 앞으로 어떻게 환경문제들을 풀어나가야 하는지에 대한 숙제를 남겼다

그림3. 현종찬의 《Clarinet and Computer 2》(2020) 공연현장

그림4. 오예민의 《Sonic Diplopia》(2020) 공연현장

현종찬, 《Clarinet and Computer2》(2020)

이 곡은 맥놀이[2]가 만들어내는 조화와 부조화 사이에서 발견한 규칙적 비트를 소재로 창작된 곡이다. 전체적으로 느린 템포로 g음에서 시작한다. 곡의 초반부에서는 클라리넷의 매우 작은 소리가 청각을 자극하며 미묘한 변화를 만들어나간다. 미분음들의 움직임은 일정한 높이를 유지하다 부딪히고, 그 지점에서 발생한 맥놀이는 이 곡의 첫 비트beat를 제시한다. 비트는 일정한 형태를 유지하고 중첩되어 집중하지 않으면 잃어버릴 수 있는 미세한 패턴을 만들어 나간다. 긴 글리산도로 패턴은 마무리되며 작품은 종료된다. 무대 세팅에서는, 연주자 곁에 나란히 세워진 한 스피커가 등장하는데, 관객이 보기에도 어떤 메시지를 전달하기 위한 오브제 역할을 할 것만 같은, 단순한 출력장치로는 보이지 않는 모습을 띄었다. 이 스피커는 두개의 유닛을 가지고 있는데, 작곡가는 각 유닛의 원형 틀을 사용하여 소리에 반응하는 비디오 맵핑을 시도하였다. 소리에 맞춰 빛이 발생하는데, 전자음향에는 윗부분 유닛이, 클라리넷의 소리에는 아랫부분 유닛이 반응하였다. 맵핑된 빛은 연주자와 한 몸인 양, 긴 음이 연주될 땐 호흡에 따라 점차 옅어졌고, 강한 슬랩텅이 연주될 땐 짧고 밝게 스쳤다. 연주자에게 쏘인 스팟 조명과 스피커의 맵핑이 더해져 곡의 분위기에 긴장감을 조성하였다. 유독 여운을 남기는 작품이었다.

오예민, 《Sonic Diplopia》(2020)

제목에서처럼 하나의 물체가 두 개의 다른 이미지로 동시에 인식되는 복시현상을 작품으로 표현하였다. 작곡가는 컴퓨터에게 음높이, 음길이, 쉼표, 붙임줄 등의 데이터를 입력하고, 마코브 체인이라는 통계학 모델을 이용하여, 가능할 법한 음들을 계산해낸다. 산출된 음들은 실시간으로 모니터에 띄워지고 연주자는 약 10마디 간격으로 올라오는 악보들을 초견으로 연주하게 된다. 무대 중앙엔 복시, 즉 여러 개의 사물이 겹쳐 보이는 현상이 영상으로 띄워진다. 대상은 연주자의 얼굴이다. 이는 곡이 진행됨에 따라 점차 여러 개의 층으로 나뉘고 중첩되며 초점을 잃은 듯 교차한다. 매끄러운 이미지보다는 굵은 픽셀을 이용한 디지털적인 효과를 주어 분열을 강조한다. 강한 멀티포닉스와 함께 화면은 픽셀 단위로 부서지고 페이드 아웃 된다. 오예민 작곡가는 프로그램 노트에 다음과 같이 설명하였다. "...한 물체나 현상을, 한 사람의 눈으로 볼 지라도 시간과 시각에 따라 달라 질수 있다는 생각을 하게 되었다. 정의라고 믿고 있던 사실 조차도 실제로는

정의가 아닐 수도 있으며, 진실은 바뀐 것이 아니라 자신의 시간과 자신의 시각이 달라진 것일 수도 있다." 우리가 마주하는 실재는 각자의 시각에 따라 의미를 달리할 수 있음을, 누군가는 사물의 진실된 모습을 끝내 찾지 못하고 중첩된 채 모호하게 인지할 수 있음을 보여주는 작품이었다.

그림 5. 임승혁의《짧아짐verkürzt IV for Clarinet》(2020) 공연현장

그림 6. 조진옥의《LoopUp for Clarinet and Live-processing》(2020)

임승혁,《짧아짐verkürzt IV for Clarinet》(2020)

이번 ELECTRONICA-IV에서 연주자가 객석, 즉 정면을 바라보고 연주하는 곡은 단 두 곡 뿐이었다. 이번 곡 역시 무대 중앙에 재생되는 비주얼 미디어가 중심이기 때문에 연주자는 측면으로 서서 연주하였다. 이 연주는 8개의 비디오로 스트리밍 되고, 비디오는 사다리꼴 모양으로 대칭되어 서로 마주보는 형태로 정렬되었다. 영상은 좌측 우측으로 나뉘게 되는데, 연주자가 연주한 특정 마디는 잠시 후 반대편에서 재현된다. 좌측은 현재 시점을 실시간으로 보여주고, 우측은 10초 뒤, 6초 뒤 동일한 영상이 재생되기에, 과거 시점을 보여준다고 할 수 있겠다. 점차 딜레이 시간은 짧아지며 사운드는 서로 겹치게 된다. 곡의 중반부를 넘어서며 연주자는 한 명이지만 여러 명이 앙상블을 하는 듯한 착시로 다가온다. 후반부로 갈 수록 키클릭과 강한 숨소리, 다양한 다이나믹과 음색의 변화로 점점 고조되고, 클라리넷의 주제음이 나오며 곡은 끝이 난다. 이렇게 기술이 발전함에 따라 앞으로는 연주회에 굳이 많은 인원이 투입되지 않아도 소수인원만으로도 그에 버금가는 효과를 나타낼 수 있게 될 것이라는 생각을 하게 되었다.

조진옥,《LoopUp for Clarinet and Live-processing》(2020)

도입부는 지속음만으로 이루어져 있는데, 이는 loop station을 통해 반복된다. 곡이 진행될수록 리드미컬한 패턴, 짧은 스타카토, 싱코페이션 등의 음들이 켜켜이 쌓여 나간다. 다양한 음색들이 컴퓨터의 프로세싱과 결합하여 쌓이고 또 해체된다. 중반부에는 고음역대의 음이 빈번히 등장하여 다소 날카롭다. 무수한 음들이 클라이막스에 오르고, 후반부엔 이제껏 쌓아 올렸던 음들이 서서히 그치며 잔잔한 비트로 마무리된다. 마지막 음은 아주 강한 멀티포닉으로 구성되어 마치 문을 세게 닫는듯, 끝을 맺는다. 무대 중앙엔 소리에 맞춰 실시간으로 반응하는 영상이 펼쳐지는데, 이는 연주자를 더욱 돋보이게 하는 요소 중 하나였다. 다른 곡에 등장하는 영상은 연주자보다 영상에 더 초점을 맞춘 무대 구성이었으나 이번 곡은 연주자를 중심으로 이루어져 있어 이 곡이 마지막 곡으로 선정된 것은 좋은 배치였다고 생각한다. 조진옥 작곡가는 사전 작품설명 영상에서 밝은 전자음악을 쓰고 싶었고 그 시도를 계속 이어나가고 있다고 설명하였다. 그는 이전 ELECTRONICA 시리즈들에서 클라리넷과 라이브 프로세싱을 위한 팝업I, II 를 선보였었는데 모두 밝고 박절적인 팝 스타일의 작품이었다. 전자음향 작품들의 전반에 대한 변화의 목소리였고 새로운 방향성을 보여준 무대였다고 생각한다.

이번 ELECTRONICA-IV 공연에서는, 여섯 개의 곡 서두에 각 곡의 작곡가가 진행한 인터뷰 영상이 삽입되었다. 인터뷰는 총 세 개의 파트로 나누어져 있는데, 첫 번째 질문은 본인 소개, 두 번째 질문은 작품 소개 그리고 세 번째 질문은 ELECTRONICA 시리즈에 대한 소개를 부탁했다. 관객들이 마지막 질문으로 이 시리즈의 목적과 의도, 그리고 방향성을 파악할 수 있어, 연주를 즐기는데 많은 도움이 되었다고 덧붙였다. 현종찬 작곡가는 이 인터뷰에서 "국내에 흔하지 않은 독주악기 연주자가 전자음악 작품을 지속적으로 연주하고 있기 때문에 연주자 개인의 업적뿐만 아니라 한국 전자음악

교육의 역사에도 큰 영향을 끼칠 것이라 생각한다"고 답변하였다. 기획자도 작곡가도 아닌 독주악기 연주자가 연주자로서 현대음악에, 그것도 전자음악에 매진하는 것은 결코 쉬운 일이 아니다. 연주자는 작곡가와는 현저히 다른 길을 걷는다. 국내 독주악기 연주자들은 작곡가들과 맞닿지 않는 평행선을 그린다. 필자는 아트디렉터로서 4년 동안 네 개의 일렉트로니카 시리즈를 관람 및 디렉팅하며, 왜 이와 같은 연주자가 더 양성되지 않는지, 혹은 양성될 수 없는지, 그 이유를 찾고자 했다. 연주자는 끊임없이 새로운 곡을 창작하는 작곡가와 달리, 이미 오래전에 만들어진 곡이라는 잣대로 기준을 세워, 이를 기반으로 역량을 평가한다. 때문에 전자음악보다는 클래식에 중점을 두고, 역사적이며 유명한 곡을 연구, 복기하여 분석한다. 그렇기 때문에 더더욱 이례적이었던 ELECTRONICA 시리즈는 연주자가 직접 기획하는 전자음악으로 국내에선 유일하다고 볼 수 있겠다. 유태선 작곡가의 "라이브 일렉트로닉스, 오디오 비주얼과 같은 창작작업에 관심을 가지고 위촉과 연주를 하시는 분이 계시다는 것에 굉장히 고무적인 마음이 들었다."의 답변과 같이, 많은 작곡가들은 ELECTRONICA시리즈와 같은 실험적 토대가 될 수 있는 연주회가 더 기획되기를 바라고 있다.

예술은 작품을 통해 사회적 메시지를 전달하는데 가장 자유롭고 제약이 적은 매체이다. 그만큼 예술은 우리의 삶에 가까우면서 영향력을 줄 수 있다. 예술이 자본주의 시대에 외면을 받고 있지만 많은 예술가들로 인해 사회는 깨닫게 되고 변화하게 될 것이다. 테크놀로지의 발전과 함께 수많은 예술가들이 새로운 실험의 장을 기획해나가고 있다. 이와 같은 도전적인 창작, 연주활동이 자유롭게 펼쳐질 수 있도록, 더 많은 지원사업이 창출되기를 바란다. 2021년에 발표될 ELECTRONICA-V의 새로운 모습을 기대하며 전자음악 활성화에 힘쓰는 모든 예술가들에게 응원의 메시지를 보낸다.

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1 화이트큐브 - 사면이 흰 벽으로 이루어진 공간, 흔히 미술 작품을 전시하는 갤러리 공간으로 사용된다.

2 맥놀이 - 진동수가 거의 유사한 두 소리를 중첩시켜 재생하였을 때, 두 파동이 합쳐진 합성파의 위상차에 의해 일정하게 진폭이 커졌다 작아졌다 하는 현상.

CALL FOR WORKS / Seoul International Computer Music Festival 2021

The Korean Electro-Acoustic Music Society is proud to announce the Seoul International Computer Music Festival (SICMF) 2021 in October 15-17.

CATEGORIES

1. Tape (Fixed media) music
2. Electro-acoustic music (tape or live) with instruments (up to 4 players)
3. Live electro-acoustic music
4. Audio-visual media art
5. Any other kinds of electronic music

RULES & REGULATIONS

1. The submitted work has to be composed after 2016.
2. The duration has to be less than 12 minutes.
3. For the works of the category #2, the number of players is limited to 4.
4. For performances requiring non-standard or special instruments, composers are responsible for providing the instruments and the performers on location.
5. Channels for audio playback are limited to 8 channels.
6. Up to two works may be submitted, but they must belong to different categories.
7. Attendance at the festival is required for all participants

SUBMISSION DEADLINE (ONLINE)

31 May 2021, 6 pm (UTC+9)

SUPPORT POLICY

We agree to pay all costs for performing selected works (performer fees (up to 4 performers), instrument rental, etc).

* This policy may be subject to change.

HOW TO SUBMIT

1. Email submission.
- Send an email to master@keams.org with the link to the files(refer to #2 and #3 described below)
- Do NOT attach the files but send us the link. Use the web services such as dropbox.com, wetransfer.com.

2. CMT submission.
- go and register at https://cmt3.research.microsoft.com/

3. Media Files - Audio file(s) must be in stereo (either mp3, AIFF, or WAV)
- For the category #2 and #3: the recorded audio file and/or related files(patches, documents, programs, etc.)
- For the category #2: the score (PDF)
- For the category #4: the video file in any format (mpeg, mov, avi, etc.). Size of the file should, however, not be bigger than 1GB. (You may submit a YouTube or Vimeo link.)

4. Document (format should be either TEXT, RTF, or DOC, but NOT PDF) that includes the following information:
- Last Name
- First Name
- Nationality
- Email
- Homepage (if any)
- Biography
- Title of work
- Duration
- Category
- Instruments (if any)
- Number of Audio Output Channels
- Program Notes
- World premiere / Asia premiere / Korea premiere (if applied)
- Special Requirements for the Performance (if any)

5. Submission Fee
Submission fee US$20 per work is required.

FOR FURTHER INFORMATION

master@keams.org
http://www.keams.org

서울국제컴퓨터음악제 2021 작품 공모

한국전자음악협회는 서울국제컴퓨터음악제 2021에 연주될 작품들을 공모합니다. 서울국제컴퓨터음악제 2021는 10월 15일부터 10월 17일까지 열릴 예정입니다.

공모 분야

1. 테입(Fixed media) 음악
2. 악기(4명 이내)와 전자음악(테입 혹은 라이브)
3. 라이브 전자음악(악기 없이)
4. 오디오-비주얼 미디어 작품
5. 그 외 다양한 종류의 일렉트로닉 음악

공모 규정

1. 작품은 2017년 이후 작곡된 것이어야 함
2. 작품의 길이는 12분 이내여야 함
3. 악기를 동반한 전자음악일 경우 연주자는 3명 이내여야 함
4. 특수한 악기를 동반한 음악일 경우 작곡가의 책임 하에 악기와 연주자를 동반하여야 함
5. 모든 작품은 8채널까지만 가능
6. 두 작품까지 접수 가능하나 서로 다른 공모분야의 작품이어야 함
7. 선정될 경우 페스티벌에 반드시 참가하여야 함

공모 접수 마감

2021년 5월 31일 오후6시 (서울 시각, UTC+9)

지원정책

1. 당선된 작품의 연주에 필요한 비용(연주자 사례비(4명까지), 악기 렌탈비 등)은 본 회가 지불합니다.

* 이 정책은 본 회의 사정에 따라 변경될 수 있습니다.

접수 방법

1. 온라인 접수

- 이메일 master@keams.org로 작품 관련 파일(아래 2,3번 참조)들을 보낼 것
- 단, 첨부파일로 보내지 말고 dropbox.com, wetransfer.com 등의 서비스를 이용하여 링크를 제출

2. Conference Managememt Toolkit 접수

- https://cmt3.research.microsoft.com/에서 회원 등록

3. 작품 파일

- 오디오 파일은 반드시 스테레오 버전으로 보낼 것 (포맷: mp3, AIFF, WAV 중 택일)
- 라이브 전자음악일 경우: 녹음된 오디오 파일(있을 경우, mp3)과 관련 파일(패치, 도큐먼트, 프로그램 등)을 업로드
- 악기를 동반한 전자음악일 경우 반드시 악보 (PDF) 업로드
- 오디오-비주얼 작품일 경우: 영상 파일은 mp4, mov, avi 등의 포맷으로 올리되, 전체 용량이 1GB를 넘지 않게 할 것 (youtube 혹은 vimeo 링크를 제출해도 무방)

4. 다음 정보를 담은 도큐먼트 파일 업로드 (포맷: TEXT, RTF, DOC, HWP 중 택일 / PDF는 제출 금지)

- 성명
- 국적
- 전화 (휴대전화)
- 이메일
- 홈페이지 (있을 경우)
- 프로필 (Biography)
- 작품제목
- 작품길이
- 공모분야
- 악기 (있을 경우)
- 오디오 아웃풋 채널 수
- 프로그램 노트
- 세계 초연/ 아시아 초연/ 한국 초연 (해당사항이 있을 경우)
- 연주시 특별히 필요한 요구 사항 (있을 경우)

5. 참가비

참가비는 한 작품 당 US$20(한화 25,000원)을 내셔야 합니다.

(한국전자음악협회 회원은 공모 참가비 면제)

문의 및 기타 정보

master@keams.org

http://www.keams.org

fest-m 2021 작품공모

fest-m은 젊고 개성있는 작곡가들의 컴퓨터 음악이 공연되는 축제입니다. fest-m은 한국전자음악협회가 주최하고 매년 공모를 통해 선정된 작품이 연주됩니다. 올해에도 젊은 작곡가 여러분들의 많은 응모 바랍니다.
fest-m 2021는 4월말~5월초에 열릴 예정입니다.

응모 작품 분야
1. 테이프 음악
2. 라이브 전자 음악 (인성 혹은 악기와 전자 음악)
3. 오디오-비주얼 작품
4. 실험적 전자음악 작품 (EDM과 같은 대중적 작품 포함)

제출할 것
1. 다음 항목을 담은 문서
   - 성명
   - 성별
   - 생년월일
   - 전화 (휴대전화)
   - 이메일
   - 작품 제목
   - 작품 길이
   - 공모 분야
   - 악기 (있을 경우)
   - 오디오 아웃풋 채널 수
   - 프로그램 노트
   - 프로필
   - 연주시 특별히 필요한 요구 사항 (있을 경우)
2. 작품해설
3. 관련자료 (악보, 녹음, 공연을 위한 Max패치, 비디오 등)
4. 공연에 필요한 장비 목록 및 세팅

응모 마감
2021년 3월 31일 오후 6시

응모 방법 1: master@keams.org로 지원자료 제출.
응모 방법 2: https://cmt3.research.microsoft.com/에서 회원 등록 후 지원.

응모 규정 및 참고 사항
1. 1987년 1월 1일 이후 출생 작곡가
2. 작품의 길이는 10분 이내
3. 한국전자음악협회에서는 공연장 및 공연 장비를 제공하며 연주자를 위한 소정의 연주료를 지원합니다.
4. 별도의 응모 접수비는 없습니다.
5. 응모된 작품은 예선 심의를 거쳐 한국전자음악협회 홈페이지(http://www.keams.org)에 공지됩니다.
6. 공연당일 실연 심사를 통해 공연의 우수작은 서울국제컴퓨터음악제 2021에 초대될 수 있습니다.

더 자세한 문의 master@keams.org

Call for Proposals

The Korea Electro-Acoustic Music Society (KEAMS) announces a call for proposals for the 2021 KEAMS Annual Conference (KEAMSAC) and the journal *Emille*.

If you want your paper to be considered for the 2021 KEAMS Conference, please send an abstract or proposal (maximum of 2,000-characters including spaces) and curriculum vitae as PDF documents by 31 May. Selected papers from the conference will be published in *Emille* Vol. 19. emille[at]keams.org

KEAMSAC was formed to promote active research and discussion on electro-acoustic music, and this year's conference will be held in Oct. 15-17 in Seoul, Korea. This event will go with the Seoul International Computer Music Festival (SICMF).
http://www.computermusic.asia/

Language
Conference Presentation: English
Conference Article: English or Korean
Journal Article: English or Korean

Categories
For the KEAMS conference, the following topics are encouraged:

a) Creative Encounters between Music and Science
b) Multidisciplinary or Interdisciplinary Research
(co-authors acceptable)
c) Systematic Musicology
- Computational Musicology
- Computational Music Theory
d) Analysis of Electronic and Computer-based Music
e) Sound Synthesis
f) Music Psychology
g) Instrumentation
h) Development of Electronically-extended
Musical Instruments
i) Music Software Engineering
j) Artificial Musical Intelligence
k) Computer-aided Composition/Analysis
l) Automatic Composition
m) Aesthetics
etc.

제안서 공모

한국전자음악협회 (KEAMS)는 2021년도 연례학술대회 (KEAMSAC)에서 발표될 연구물과 학술지 <컴퓨터음악저널 에밀레>에 게재될 논문의 제안서를 모집합니다.

저희 협회의 연례 학술대회 (KEAMSAC)는 전자 음악에 대한 활발한 연구 및 토론을 촉진하기 위해 만들어졌으며, 이번 학술대회는 10월 15일부터 17일까지 서울에서 개최될 예정입니다. 이 행사는 전자음악을 연구하는 학자와 예술가들의 다양한 교류를 위해 서울국제컴퓨터음악제 SICMF와 함께 진행됩니다. 최종 선별된 연구물은 선정 과정을 거쳐 <컴퓨터음악저널 에밀레> 제19호에 게재됩니다.
http://www.computermusic.asia/

연구물을 2021년도 전자음악협회의 연례 학술대회에서 선보이고 싶으신 분들은 제안서(공백을 포함하여 최대 2000자까지)를 약력과 함께 PDF 문서로 작성하여 emille[at]keams.org로 5월 31일까지 보내주십시오.

언어
학술대회 발표: 영어(요청에 따라 한글발표를 위한 통역을 사용할 수 있습니다.)
학술대회 논문: 영어 또는 한글
학술지 논문: 영어 또는 한글

분야
한국전자음악협회는 다음과 같은 다양한 분야의 연구물에 귀를 기울이고 있습니다:

a) 음악과 과학의 창조적인 만남
b) 다학제적 연구 및 학제간 연구
(여러 저자의 공동 연구물 포함)
c) 체계적 음악학
- 전산처리를 기반으로 하는 음악학
- 음악이론
d) 전자음악 및 컴퓨터음악 작품의 분석
e) 음향 합성
f) 음악 심리학
g) 악기론
h) 전자적인 수단을 통행 확장된
새로운 악기의 개발
i) 음악 소프트웨어 공학
j) 음악 인공 지능
k) 컴퓨터의 도움을 받는 작곡 및 분석
l) 자동 작곡
m) 미학
기타.

Important Dates
- Deadline for Proposal Submission
  May 31, 2021

- Notification of Acceptance of the Proposal
  July 31, 2021

- Paper Submission for the Conference Proceedings
  September 30, 2021

- Conference
  October 15-17, 2021

- Notification of Selected Paper for the Journal *Emille*
  November 30, 2021

- Deadline for Final Paper Submission
  December 20, 2021

Session Formats

1. Presentations
- Each session will consist of three to four presentations.
- Each paper will be presented in person for about 25 minutes followed by ca. 5 minutes of discussion.
- Video conferencing over the Internet may situationally be available.

2. Keynote presentation
- A keynote speaker will be given 50 minutes to address, followed by 10 minutes of Q&A.

3. Workshops
- The length of each session will be around 90 minutes.
- Each workshop may consist of two to three sessions in one to two days.

Fees and Accommodation

Thanks to the financial support of the Art Council Korea, the registration and publication fee will be waived, and accommodation also will be provided for two nights.

It is also possible for students and non-experts in the fields mentioned above to submit proposals for the conference and the journal, *Emille*. All proposals will be screened by the program committee and selected solely based on the quality of the research and topic.

We are welcome any ideas for electro-acoustic music research from you, and believe them to be precious assets for the conference and the journal.

Supported by Arts Council Korea

주요 일정
- 제안서 제출 마감일
  2021년 5월 31일

- 제안서 승인 통보일
  2021년 7월 31일

- 학술대회 원고 마감일
  2021년 9월 30일

- 학술대회
  2021년 10월 15-17일

- 학술지 논문 게재 여부 통보일
  2021년 11월 30일

- 최종 원고 제출
  2021년 12월 20일

Session 구성

1. 발표
- 하나의 session은 3-4개 정도의 발표로 구성될 수 있습니다.
- 각 발표자에게 주어지는 시간은 약 25분이며 약 5분간 질의 문답 시간이 뒤따릅니다.
- 경우에 따라 인터넷 화상 채팅을 이용한 발표도 가능합니다.

2. 기조 연설
- 기조 연설자는 50분의 연설과 10분의 질의응답의 시간이 주어집니다.

3. 워크숍
- 워크숍 각 세션의 시간은 90분 내외입니다.
- 워크숍은 1-2일에 걸쳐 2-3개의 세션으로 구성될 수 있습니다.

비용 및 숙박

한국문화예술위원회(ARKO)의 재정 지원에 힘입어 이 행사에는 참가비와 논문 게재료가 없으며 이틀간의 숙박이 제공됩니다.

연구물의 내용에 따라 학생과 비전공자에게도 학술대회 참가 및 논문 게재의 기회가 주어집니다.
제출된 모든 제안서는 학술지 조직 위원회에 의해 면밀히 평가되며, 오로지 연구 내용의 우수성에 의해서만 채택됩니다.

여러분들의 작은 아이디어 하나가 학술대회와 에밀레를 풍성하게 합니다. 많은 응모 바랍니다.

후원: 한국문화예술위원회