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Procedia - Social and Behavioral Sciences 216 (2016) 861 – 873

Procedia
Social and Behavioral Sciences

Architecture and Engineering Technology (AET) 14- 16 October 2015

Soundscapes of Digital Morphogenesis in Architecture which created from Musical Algorithm

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Abstract

Music and architecture have made use of mathematical proportions throughout the history for the purpose of creating acoustic and visual forms. The reason for this is the aesthetic pursuit of both disciplines since centuries. Mathematics is one of the most important factors that influence aesthetic results. While forming their abstract aesthetic compositions the musicians use the musical notes that have definite frequency values. Each of these frequency values are defined by one integer. Every classical music artist uses the fractal sequencing of these frequencies. On the other hand we encounter hundreds of silent formats which are produced using mathematical ideas. In this context if we think of the interdisciplinary interaction between music and architecture no form is ever silent. In this study, the intersection of two disciplines will be examined in the perspective of architecture; a stumper and interrogative start for pursuit of architectural forms of the present day with the transformation of auditory forms to visual forms will be made; and a basis will be provided to be able to discuss the innovations that the spaces, structures and auditory experiences which can be formed by obtaining musical codes bring.

Keywords:Transcoding, Acoustic, Computational Design, Transdisciplinary framework, Architectural design;

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doi:10.1016/j.sbspro.2015.12.083

1. Introduction

1.1. Architecture and process

In the modern day architecture, along with the digital Technologies, the necessity for designing the design process itself, not only designing the absolute product, has initiated many novel discussions. Building the process of architectural design is about defining the relations of information that are influential to architectural design and are interactive and multi-directional. Computational thought and developing information technologies constitute a significant interface in accordance with the flow of information in architectural design and with the systematization and clarification of the "process".

In our day, building the "process" steps forward in defining various systems with the computational theory, rather than stable equations. By this way, when the processes or formations in nature are planned and defined with the computational theory; system can be examined with its multi-dimensional, dynamic/mobile/kinetic relations and correlations, instead of being examined with static/stable digital mathematical equations. In the flow of space-time information, digital mathematics is replaced by the relational operations and algorithms. (1) Digital features of the said system are left behind by its topological features .The information that we obtain and experience from our environment can alter with the computer based models. (2)

1.2. Computational theory as a method of transcoding

Frederick Jameson who considers the theory as a tool of compromise in order to comprehend two or more elements, suggested the term "transcoding" (3) defines transcoding "creating a series of terms that provide the formation of the needed terminology to analyze and express two different sorts of material or context, or of structural reality in different levels". Based upon this description, it could be possible to accept the computational theory as a sort of the transcoding method and to define it as an interface for the expression and interpretation of natural/artificial reality. Computational theory and thought renders the evaluation of every systematic process that follows certain rules by providing a common platform in order to examine the relational processes and organizations in different contexts, possible with the computational setups. (4) By means of computer based tools and computational thought, description of formation and processes through digital models, under a common thought system and with a common structure, provides an environment for sharing interdisciplinary ideas. That the computational theory constitutes an interface for the transcoding, also reinforces the information Exchange between architecture and other disciplines.

1.3. Transcoding in music and architecture

Everything that exists in natural reality has an algorithm. This algorithm, while changing from one culture to another, affects the auditory and visual design by getting deep in one's self. (5) As the auditory and visual design includes three dimensional practices; their interaction creates intense, spatial experiences. Visual forms are the firstly perceived elements that create emotional effect and serve aesthetic purposes. The common point of the two disciplines is the longstanding pursuit of aesthetics.

Throughout the history, designers from both fields use various ratios introduced by the mathematical studies in order to create their visual and/or auditory forms. This is because, in the Works of design processes, there exist different pursuits of aesthetics regardless of the senses aimed by the absolute product. In this respect, the common ground of both emerges as algorithmic ideas. Those nature-based algorithms are one of the most important factors affecting aesthetic results. For instance, musicians use certain arrangement of notes that have certain frequency values while generating the aesthetic compositions. Those frequency values are each identified with a whole number, used also by space designers. Thus, both designers (musician and architect) generate hundreds of silent or voiced forms by using algorithmic ideas. Considering the interdisciplinary interaction of music and architecture in this context, no form is ever silent. That the design enables the different perspectives to designer by appealing to his unusual perceptions, scents and feelings, lead to obtaining new products. Therefore, the fact that the artwork appeals to different senses at once, provides a basis for the generation of four dimensional forms that cannot be obtained

through the traditional design process. In this paper, these four dimensional forms achieve multiple sound effects within one space.

2. Theory

2.1. Objectives and methodology

The objective of the research is to define the frequency ranges and frequency arrangements of a classical music work (using rhinoceros and grasshopper software) in digital environment and to generate smart forms that are geometrical and architectural; and a basis will be provided to be able to discuss the innovations that the spaces, structures and auditory experiences which can be formed by obtaining musical codes bring. In order to achieve this, the study primarily takes the advantage of creative thinking and transmodality. Therefore, transvergence, which can be described as the moment of craze and blackout, constitutes the design method of this thesis as of the method of the emergence of creative thinking in design. Transvergence allows the creation of the brand new and unpredictable space as a result of the change of perspective brought by information external to architecture, at the stage of the generation of probable prototype scenarios in order to improve the existing case. This perspective is takes its form by the simultaneous and hybrid use of the research methods, that are either qualitative (perception, thinking simultaneously etc.) or quantative (digital, computational, algorithmic, etc.), in the frame of critical thinking. Transvergence methodology; permits the evolution of the conventional information generated by the architectural design discipline, and the design of the unexpected. 6 In order to realize the transvergence, the designer is required to deterritorialize (him)self by, for a moment, getting away from the taught, strict disciplinary rules; and is required to think laterally by forcing his own disciplinary knowledge. This constitutes the only way to have and organless body and to reach beyond criticism and the right question, in other words, creative thinking.

2.2. Form generation by transvergence method

2.2.1.Ulvi Cemal Erkin-Opus#1

The study has previously its infrastructure set up in Istanbul Technical University, certain trials in its scope has been made and it remains open to improvement. The systematization of the process through the Grasshopper Software is aimed. Considering the previous studies, various approaches exist for the generation of forms in architectural design. The use of existing rhythm in the music and the use of features of this rhythm in generating new forms might arise as an approach that reorients the solution seeking supporting the design. In this paper, the geometrical setup of frequency values belonging to a given musical piece will be examined, a model that can be guiding to the generation of new designs will be set based upon fractal geometry and the processes of this model will be recorded. Within the scope of the research, Piano Sonata - 1st Movement (Allegro) by Ulvi Cemal ERKIN, due to its algorithmic layout, is selected. In order to generate the model, the method below can be followed. (Figure 1)

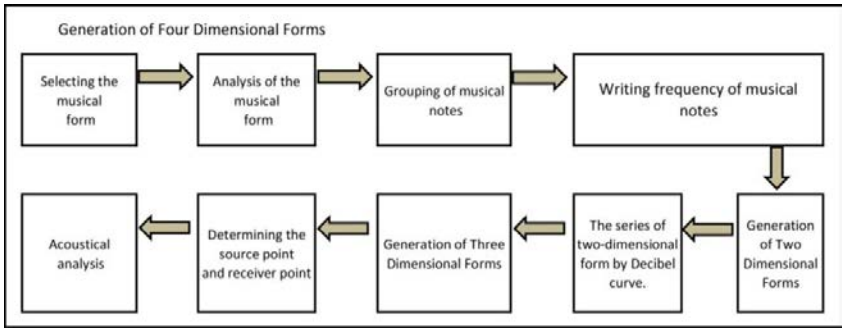


Fig. 1. Generation of four dimensional forms

2.2.1.1. Generation of two dimensional forms

In order to generate the structure, the sayings of Prof. Dr. Cihan Orhan; "… to keep two notes together simply means perceiving two frequencies or two digits and the ratio between those digits" constitute the start point. (9) According to this interpretation, perceiving a piece is indeed to perceive the frequency values of and fractal relation between the notes. Every musical instrument has a certain frequency range.

The method used for generation of two dimensional forms begins with the analysis of the notes until the end of the each bar line. (Table 1) The work is numbered, starting from the bar line, from 1 to 110. Frequency values of right and left hand on the same bar line are written in the boxes one under the other, from smaller to greater number. The obtained frequency values are used as outputs to generate the three-dimensional forms.

Table 1. Frequency Analysis

RIGHT HAND									
11	12	13	14	15	16	17	18	19	20
La-440.0		Si-493.88	Re-587.3	Do-554.37	Re-587.33	Mi-659.25	Mi-698.46	Fa-739.99	Sol-830.6
Mi-329.6	Sol-392.0	La-440.0	Si-493.25	Si-493.25	Si-493.25	Re-587.33	Re-587.33	Re-587.33	Re-587.3
Sib-233.0	La-220.0	Mi-329.63	Mi329.63	Mi-329.63	Mi329.63	Mi329.63	Sol-392.00	Mi-329.63	Fa 369.9
		Re-293.66		Re-293.66			Fa-349.23	Re-293.66	Sol.392.0
LEFT HAND									
11	12	13	14	15	16	17	18	19	20
Fa-174.61	Mi-164.81	Re-146.8	Do-138.5	Si-123.47	La-110.0	Sol-97.99	Fa-92.49	Mi-82.407	Re-73.416
									Do-65.406
Fa-87.307	Mi-82.407	Re-73.41	Do-69.29	Si-61.735	La-55.0	Sol-48.99	Fa-46.24	Mi-41.203	Re-36.708
									Do-32.703

Looking through the analyses, 11th section is comprised of one beat quarter note – the note la 440 Hz, ½ beat eighth note, the note mi 329.63 Hz, Sib 233.63 Hz, fa 174.61 Hz and fa 87.307 Hz. Frequency values of notes will refer to the heights of the lines going through 0 point. (Figure 2) In order to perceive the beat number in three dimensional visually; the 180/ beat number will determine, on the point that the angle indicates each beat, the angle between the lines. If we apply the same formula for the 11th section; (Total beat number: 1+ ½ + ½ + ½ + ½ = 3) 180/3=60 degrees. In the auditory form, that the note la is more dominant as a result of its beat number creates the visual pressure as well. For this reason, the angle of the note "la" with the notes "mi" and "si" occurs as a=60, while the angle between the half beat-sound notes sib and "fa" is a/2=30.

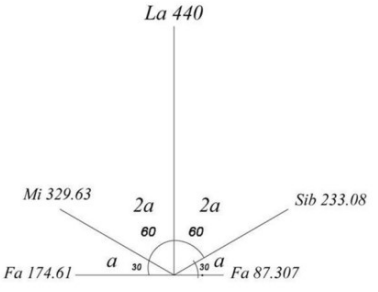


Fig. 2. 2D Figure of 11th section

The combination of these geometrical forms generated independently from the field; II dimensional forms are generated. Other forms generated using the same method is given below. See Fig. 3

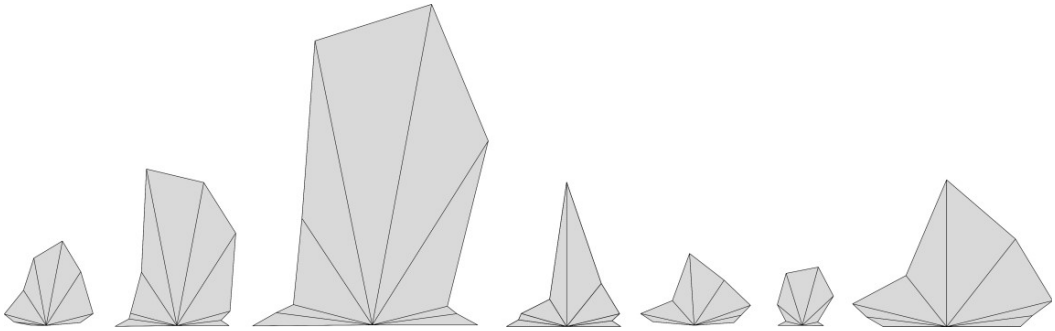


Fig. 3. 2D Forms Generated From Frequency Values

2.2.1.2. Generation of Three Dimensional Form

In the generation of the three dimensional forms, we deal with the concept “tempo”. In musical terminology, tempo is the pace or speed of a given piece. Being one of the important components of sensation, tempo is also the determinant of the difficulty of performing a musical piece and the mood that is intended to be transformed by a musical work. Tempo of a musical work is generally stated in the beginning of the piece. In modern music, it is determined by Beats per minute (bpm). Usages such as "♪ = 120" showing how many times a given value should be repeated in a minute or such as “80 bpm” indicating only the beat number etc. are common. As this value increases, the pace of a piece becomes increased as the number of notes will rise. The increase in the pace makes various effects on people. These terms will be used for generation of three dimensional forms and will indicate the distances between the set of three dimensional elements. The Bmp number and two dimensional forms are inversely proportional so that visual effects are given in the correct way.

Regarding the example of Ulvi Cemal Erkin, the tempo of the work is allegro. The elements placed on a straight, determinated axis are as seen in the Figure 4.

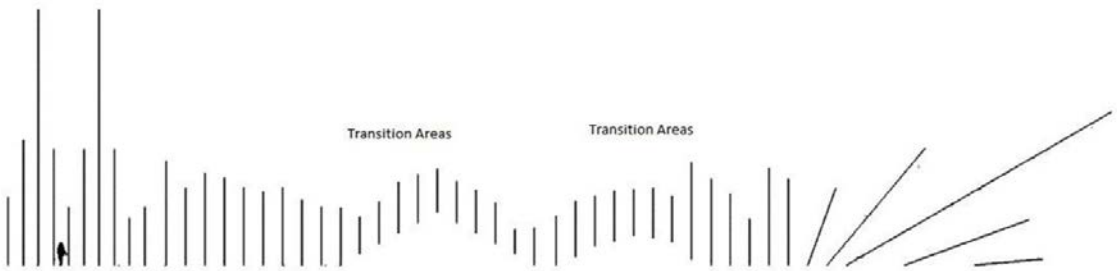


Fig. 4. Placement of 2D Elements

In the process of setting the form in the fourth dimension, the elements comprising the structure of the form are connected as in the composition. Pulling the large area off the land in accordance with the human scale is planned. In the generated form, the strong parts of the composition are arranged as loaded surfaces; the moderately strong parts are arranged as half empty and weak; the part that is consisted of rests shaping no form according to analysis is arranged as empty, the mid-section of the piece is arranged as to be consisted only of structure. (Figure 5). The 3D model of the generated form is brought. (Figure 6)

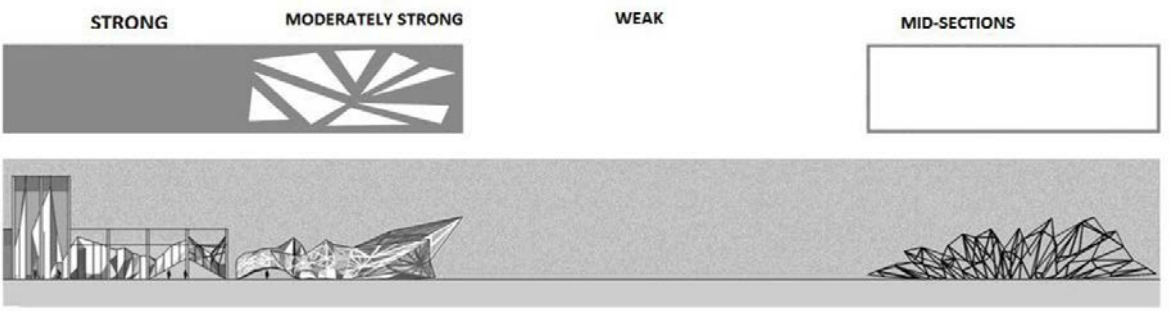


Fig. 5. Generation of the Surfaces

Fig. 6. 3D Model

OPUS #1 is designed to recalibrate the soundscape of the existing site allowing for differenced acoustic and programmatic conditions to occur. Both formal ranges and thresholds within a patterned space differentiate potential experiences and events. Each iteration is tested by placing sound source and sound receivers at different locations. As an implantable architecture, the programmatic emphasis is inherently not related to a specific event, but rather to the differentiated and updatable sound ecology, an argument used to support of a reconfigurable program. Program is therefore assumed by both site and sound, as sound is not constrained by formal elements, but rather, is its own version of one.

2.2.2. Bela Bartok-Opus#2

Fractal geometry, Fibonacci numbers, Golden Ratio that are constantly used in musical compositions are seen in the compositions of many composers. These ratios are often found in works of Béla Bartok according to analyses made by various theoreticians in second section. (7) (8) For this reason, to generate a form, first, Jeering Song by Béla Bartok having a simpler structure is selected. Each work is consisted of arrangement of notes, frequency values performed with certain tones and order. There are inverse relations and harmonic transitions between musical activities. Larger patterns are generated by classification of small patterns. Larger patterns are mostly the main elements of transitions belonging to small patterns.

2.2.2.1. Analysis of the Musical Form

In this work, the right hand in the bar 25 comprises the repetition of the first meter. No other repetition is observed besides. At this stage, in the second section, a formal analysis will be performed based on the cantor set of Solomon and the work will be divided into smaller pieces and re-grouped. Those groups are note groups being played simultaneously. The formal analysis of the composition is seen in figure 7.

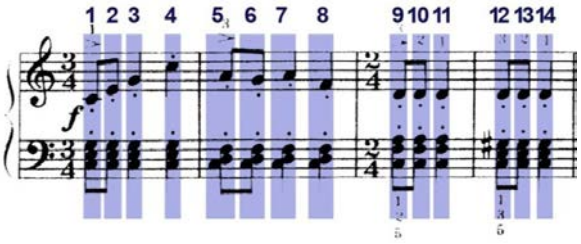


Fig. 7. Grouping musical notes

The first layer constitutes the refined features of a given composition. The piece containing 74 bars is divided into two equal pieces as 1-37 A and 37-74 B. This division demonstrates the symmetrical balance of two equal pieces. Then each part is divided into 124 subsections showing the simultaneously played notes. In conclusion, the meter is the simple notes of one beats each. By this way, we can see that each serial dual division of 37 bars consist the smaller repetitive pieces of large meter.

2.2.2.2. Generation of Two Dimensional Forms

This process is followed by generating two dimensional forms. The frequency values of notes are needed in generation of two dimensional forms. As seen in the Table 2, the frequency values of simultaneously played notes are written as shown below providing the consideration of beat values.

Table 2. 1-8 Frequency Analysis

RIGHT HAND							
1	2	3	4	5	6	7	8
Do-261.626	Mi-329.628	Sol-329.0	Do-523.251	La-440.0	Sol-329.0	La-440.0	Sol-329.0
LEFT HAND							
1	2	3	4	5	6	7	8
Sol-195.998	Sol-195.998	Sol-195.998	Sol-195.998	Fa-174.614	Fa-174.614	Fa-174.614	Fa-174.614
Mi-164.814	Mi-164.814	Mi-164.814	Mi-164.814	Re-146.832	Re-146.832	Re-146.832	Re-146.832
Do-130.813	Do-130.813	Do-130.813	Do-130.813	Do-130.813	Do-130.813	Do-130.813	Do-130.813

First section is consisted of four notes having equal beats: Do, Sol, Mi and Do. If notes will arise from the half circle and if all have the same durations; 180, half circle angle will be divided by 3 and the angle between the lines will be calculated. In section one, as 180:3=60, the angle between lines is 60. In this case, two dimensional form of section one occurs as it is seen: (Figure 8)

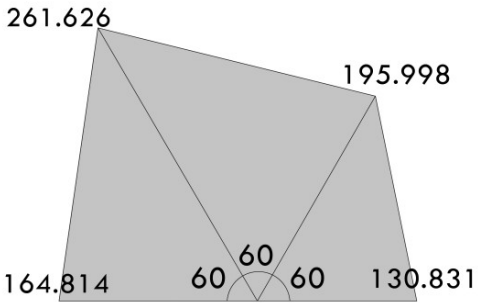


Fig. 8. 2D form of section one

When each section is set by following the same manner on Y axis, an image as in figure 9 will occur:

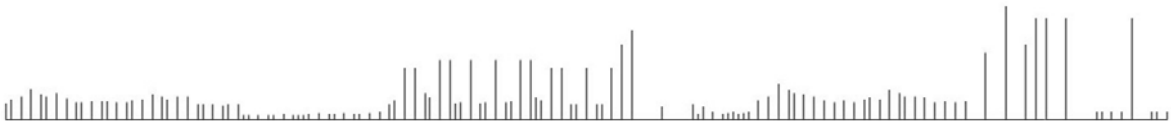


Fig. 9. 2D form of section one

The three dimensional image of the form is as it is shown below: (fig.10)

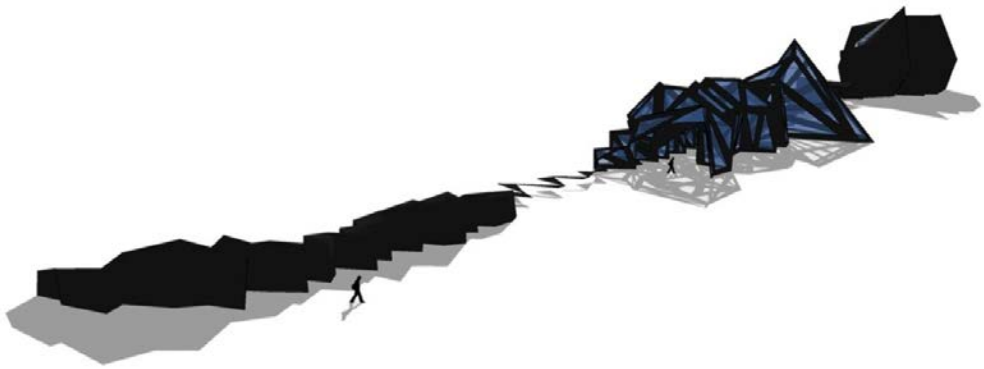


Fig. 10. 3D image of the form

3. Results

3.1. Generation of four dimensional forms

Recursive tests and acoustic analyses have been made to visual representations consisting of auditory forms in order to support conceptual infrastructure. This form aims at differentiating the soundscape of existing field providing different acoustic and programmatic conditions. It provides distinguishing experiences with different potentials within one single patterned field. Integrated parts are as a set, addressing the entire form, each form

contains its own local acoustic conditions. Just as there is form array within the form as in cantor analysis within the music, represented forms are also have the same rule with the auditory forms and figures consist "form within form".

OPUS #2 project has been given in the Figure 11 main form is made of 3 sub forms within itself. Formation reason of these sections is the part's having stop points, dual and single musical note groups. Jeering Song composition of Bela Bartok used for the project does not have a complicated-multi formed visual structure since it is a single composition.

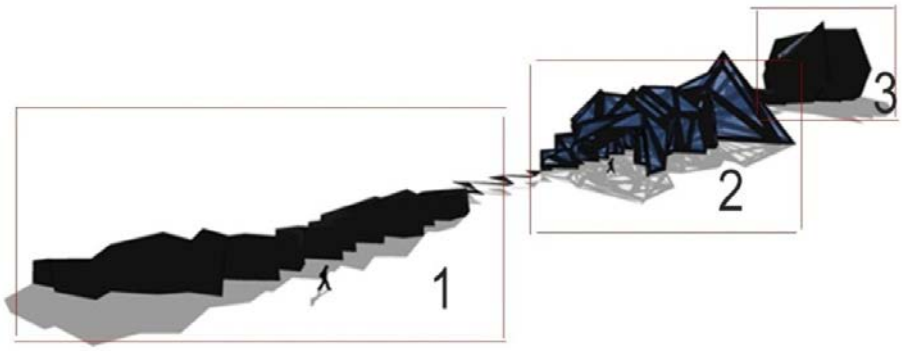
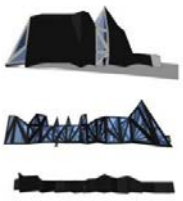


Fig. 11. 3D Section of the Form



Béla Bartók for children, vol. 1, Jeering Song in c major, No. 30								
Number of Forms	Surface /m2	Hacim/ V/m3	Ortalama Serbest Yol/m	Max Height/m	Min Height/m	f_{max}	f_{min}	RT/Reverbretation Time
1	1414,27	2638,8	7,46	14,9	1,01	1760	65,4064	1,49
2	1204,86	885,01	2,94	11,73	1,51	1318,51	65,4064	0,8
3	210,4	82,83	1,57	4,03	1,51	523,251	65,4064	0,43

Fig. 12. Values of Bela Bartok Forms in Recursive Tests

As it is seen in the chart, three forms have different volumes. Since these forms have different volumes, each of them constitutes different sound experiences within themselves. Each form has been tested to keep a source at the beginning point and a receiver in the ending point of two dimensioned form within itself. To understand the acoustic performance of an interior space, geometrical acoustic simulation is the currently accepted method. Many acoustic simulation software packages now provide valid results; however, when compared to architectural design software most of these software packages have limited abilities to actually create geometry. Therefore, the geometry is created in architectural design software, then exported, and imported into the simulation software. (10) Odeon, the simulation software used in these forms, requires simplified geometry. Three forms' acoustical analysis are as they are shown in following pages. See Fig. 13, Fig. 14, Fig.15

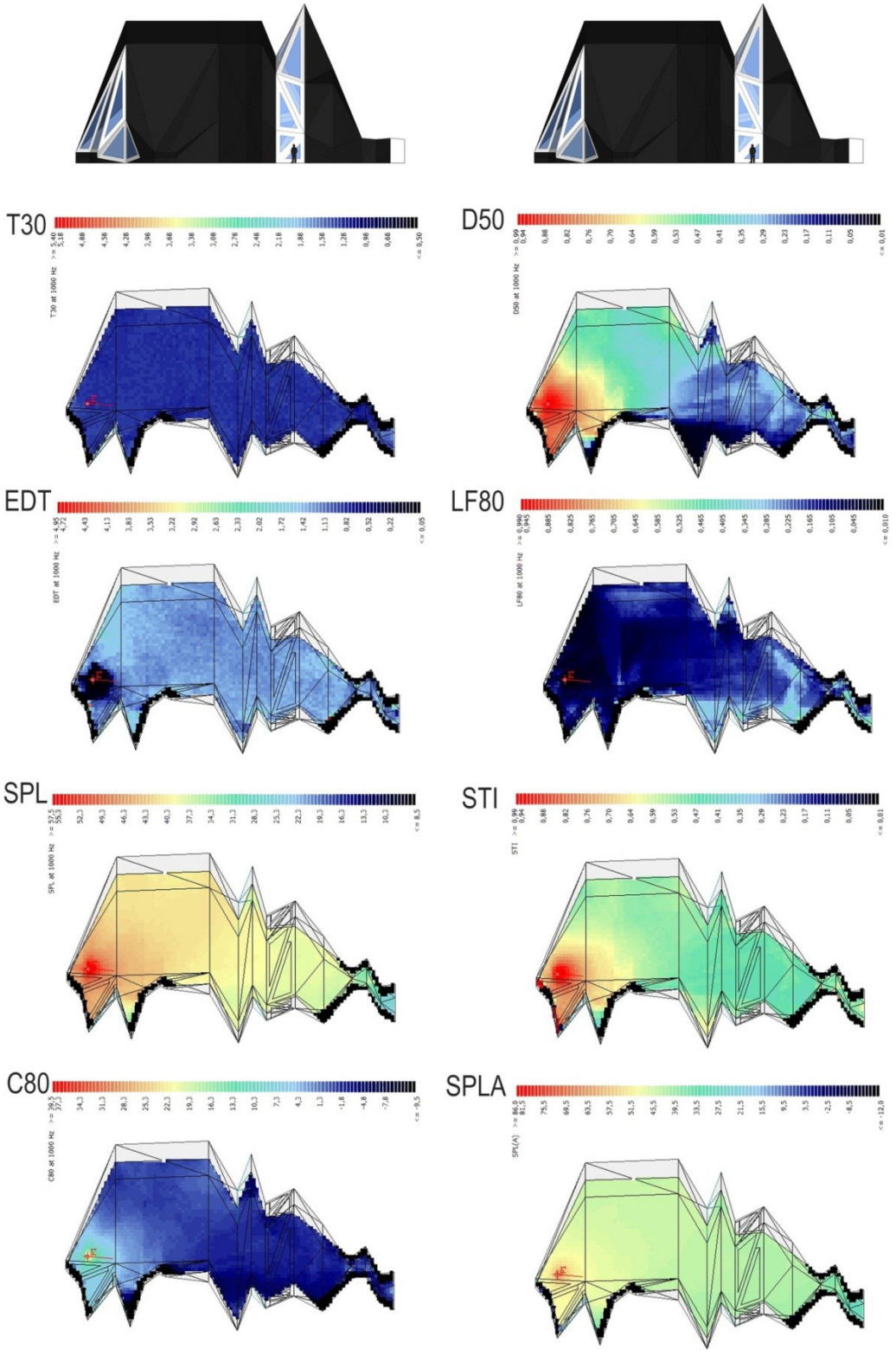


Fig. 13. Bela Bartok Form 1

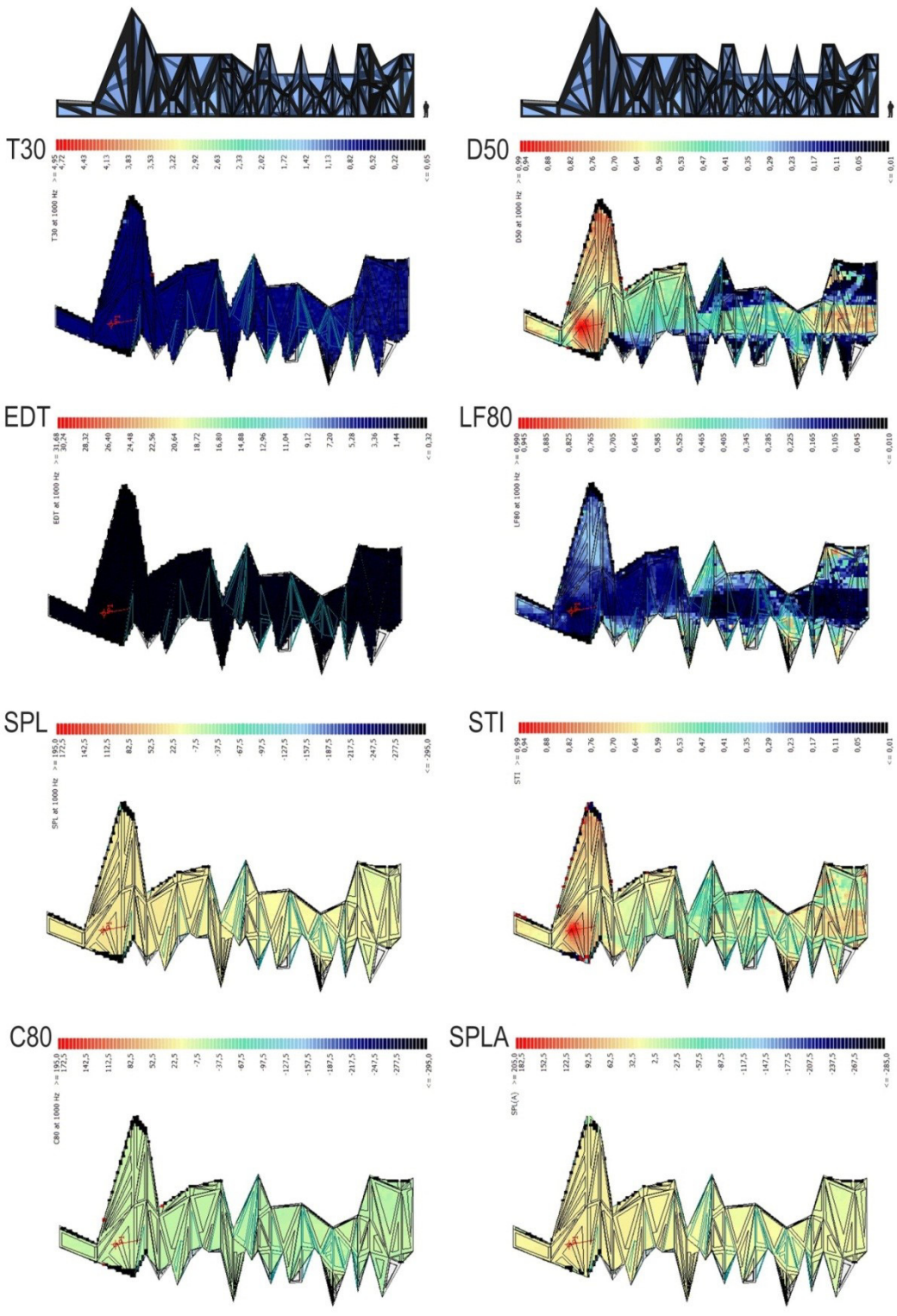


Fig. 14. Bela Bartok Form 2

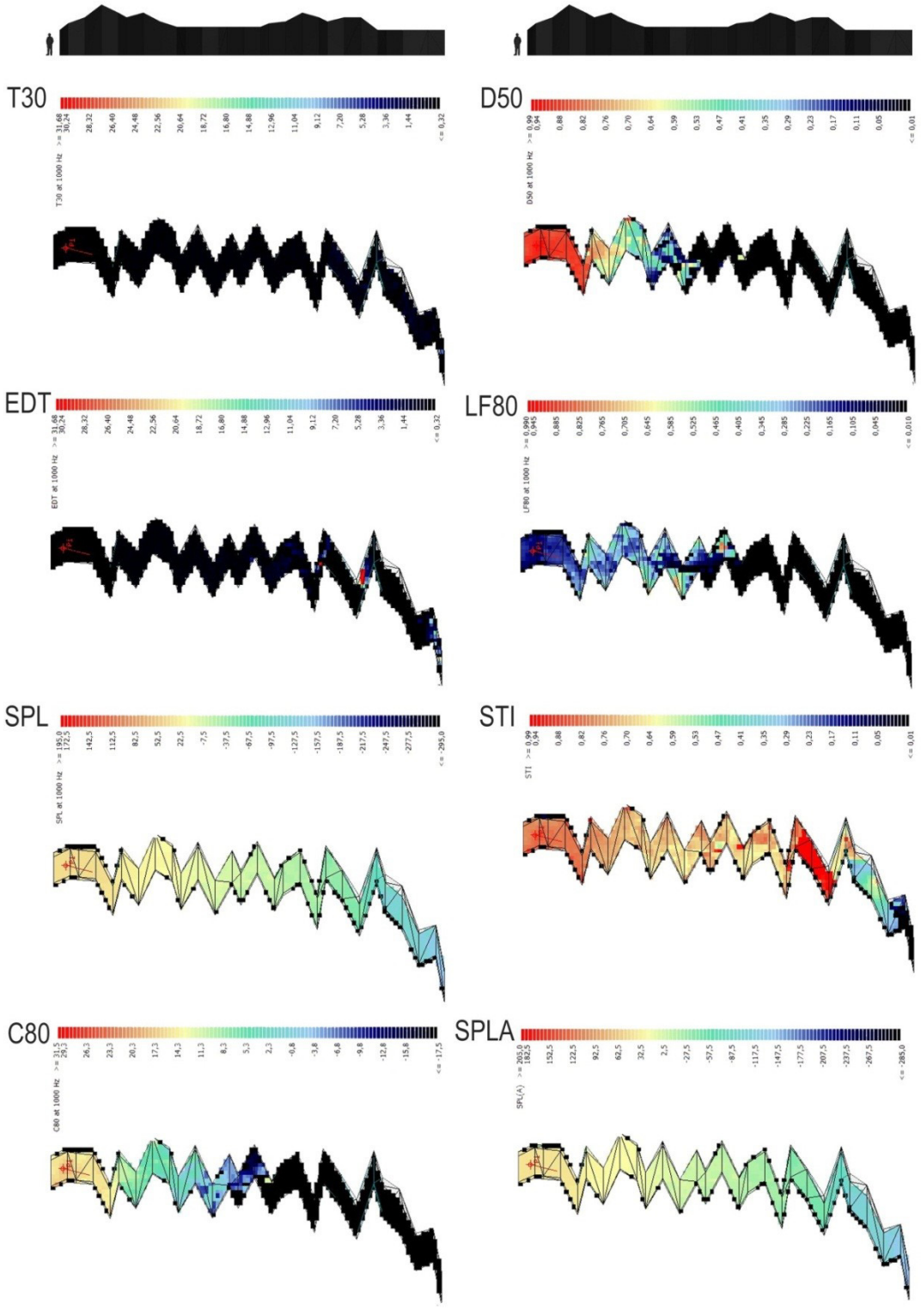


Fig. 15. Bela Bartok Form 3

4. Discussion and Conclusions

Addressing the entire form as a series of integrated parts, each node's local acoustic conditions have the ability to perform independently or act as a supplement to its neighbor node.

OPUS1# and OPUS2# are designed to recalibrate the soundscape of the existing site allowing for differenced acoustic and programmatic conditions to occur. Both formal ranges and thresholds within a patterned space differentiate potential experiences and events. In today's rapidly developing world, it is impossible to distinguish different disciplines from each other with clear cuts. A designer should destroy these borders and reach ambiguous knowledge in order keep pace with the new order and reach the new, in other words, it should design the ambiguity. As a designer of brand new order cyberspace and information technologies, it extremely provides these opportunities to us. Trans-disciplinary point of view processed in this paper shall change social meanings and physical perceptions of locations. A structure should be removed from being only a sheltering location and should be turned into a living organism that can be perceived through five sense organs. Locations processed in this paper are artificial locations and locations squeezed between the truths. Forms of structures should be perceived along with their functions and environments, result products should be re-evaluated with the user's participation in designing process. Any kind of disciplines containing mathematical codes within like music can be liable for architecture and may create a reality in the concrete world as it creates a step for the design. In the paper, it has been demonstrated that music can create a reality in the concrete world with OPUS 1 and 2 projects.

In the light of this information, a method that can be used within both studies has been developed and acoustic analyses of generated forms have been made. A base for further studies and new methods to be created other than this method has been prepared. Cyberspace and virtual environment are revolutionary for developing new methods. As it is understood from the examples, studies made recently have enabled transition from three-dimension to four-dimension in architecture and music interaction with the development of technology.

Consequently, sound is space and space is music. Also, while structures appealing to different sense organs strengthen the spatial experience of auditor, they have demonstrated the possibility of disable auditors' perceiving audio by hearing the visually. The aspect of this study which is open to criticism is forms' being hang in the cyberspace.

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