The Disassembly of a Musical Piece and its Conversion to an “Architectural” Pathway

An algorithmic approach

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Abstract. This paper presents and discusses a process of transferring the main features of a piece of music such as structure, notes etc., to a primarily spatial construction in architecture. The main objective of this effort was to convert the linearity of time during the hearing of a musical piece into a continuous pathway and an architectural stroll on a given site. To this end, the musical piece is used as a source of data, which, with the use of developed algorithms, are converted into spatial data. A purely instrumental piece, “Air,” from the suite for strings in D major by Bach, provided the source data used in the design of Park D, a section of a Cultural Park in the suburbs of Athens, Greece. The developed algorithms presented in the paper include: a) an algorithm for generating the shape of the path and the space defining elements along the path, and b) an algorithm that generates the geometry of four harmonographic structures.

Keywords. Music and Architecture; Gestalt; Design Algorithms; Harmonograph.

INTRODUCTION

Architecture and music, typically the products of dissimilar artistic media, often present a lot of striking similarities. The creators of both arts often use common tools and, in many instances, both depend upon proportions and other mathematical relationships (Tenney, J. 1977). Based on this notion, several architects have attempted to establish a relationship between the two arts that goes beyond the metaphoric or symbolic association. The work of Iannis Xenakis, such as the “City of Music,” where he used the mathematical language, to express through architecture the complexity of the language of music and the experience of sounds, has significantly enriched the research in this direction (Capanna, A., 2009; Sterken, Sv., 2009). At a different level, a product of the efforts made to establish a tighter relationship between music and architecture is the harmonograph. This is an instrument that is based on the proportions of the Pythagoras’ scale and is able to convert notes into images (Ashton, A., 2003).

A common denominator that supported several of these efforts was the assumption that the human brain perceives different artistic works with similar processes or mechanisms. These mechanisms, in the early modernist years, were interpreted by the Gestalt theory arguing that our experiences tend to be organized in a regular, orderly, symmetrical and simple manner. The laws of Gestalt that find application mainly in the visual arts, can be also applied to the interpretation of the mechanisms involved in the
perception of other artistic expressions (Desolneux, A. et al., 2008).

Taking into account existing research in the field and working in the same direction, a process of transferring the main features of a piece of music to an architectural project has been attempted and is presented in the following sections.

**DESIGNING PARK D#**

The design of a section of a Cultural Park in the suburbs of Athens, Greece, served as a test-bed for experimentation with a developed method for transferring the main features of a piece of music (structure, notes etc.) to a primarily spatial construction in architecture. The Cultural Park currently houses a sculpture hall, a theatrical scene, and a couple of smaller exhibition halls. A new section of the Cultural Park, Park D#, that embodies in its design a methodology for transferring music data into spatial data, has been proposed and is discussed here.

Notable site features that were taken into account for the proposed design were its low relief topography, a highway at one of the site boundaries, a large open parking lot at a neighboring area, sparse vegetation in the field, and a relatively small building structure, dating from the beginning of the century; this was used as support structure for Park D# to house the information desk, restrooms, administration etc.

The main feature of Park D# was the design of a music pathway that will also serve as an open-air sculpture exhibition; the stroll along this path is planned and expected to convey a combined spatial and sound experience. Park D# would also include several semi-covered station areas, the harmonographic structures, planned to host or provoke combined music-sound and art events.

Accordingly the main objective of the proposed design was to convert the linearity of time during the hearing of a musical piece into one continuous pathway on the given site. The selected piece is a
purely instrumental piece named “Air” from the suite for strings in D major by Bach (BWV 1068). A description of the developed processes and algorithms for translating the music data into spatial data in an architectural context follows.

TRANSFERRING DATA FROM MUSIC TO ARCHITECTURE
The music pathway which is the principal feature of Park D# results from a process of transferring several sets of data that derive from the selected piece of music into an architectural context.

Before the discussion of the developed processes, it needs to be mentioned that “counterpoint” refers to techniques that facilitate the knitting of two or more melodies that are expected to be heard simultaneously. “Repetition,” “opposite movement,” “imitation,” are commonly used techniques in counterpoint; analogous compositional rules, such as “array,” “symmetry” and “copy,” are met in the visual arts and architecture. Departing from this observation, the principles of Gestalt psychology can help us identify common patterns between music and architecture. The Gestalt principle of “proximity” can be used for selecting notes that are close to the time dimension of a piece, and transferring them into an architectural context, while the Gestalt principle of “similarity” can be used for selecting notes that are similar in punctuation, tone, or pattern.

The selected piece “Air” is written for four instruments, two Violins, one Viola and a Cello. The notes from these instruments are translated into spatial elements. Specifically the formulation of the stream of the music path derives from the structure of the musical composition and the musical phrases.

Accordingly the first step of the design process was to calculate the length of the music path and to place it on the site. Assuming that the walking velocity of the moving visitor remains constant, the length of his journey along the path was designed to be the same as the duration of the music piece. Next, the shape of the path had to be determined.

The shape of the path is very important as it affects the visitors experience along the path. Therefore several path shapes were examined. In all instances the shapes were based on a hypothesis that...
derived from the need for an assumed movement and a perceptual pattern. Several path shapes have been derived ranging from a purely linear path to various spiral and curvilinear formations. According to the set objective, the simplest path shape would be the preferred one as long as specific requirements with regard to the visitors movement and perceptual field were met. After several path shapes were ruled out, the selected path configuration was the one described below.

The number of curves along the path was determined by: a) the basic structure of the suite, which is A-A/B-B, b) the perceptual changes of the musical “phrases” and c) the site characteristics and topography (Figures 1 and 2).

At a following stage, in order to determine the features of the path, the Gestalt psychology principles were used for setting criteria for categorizing and grouping the notes. Throughout the piece there is a clear differentiation of the role of the notes. So, along the path, the musical notes are represented by spatial elements, organized into three distinct “attention groups” that reflect the distinctive roles of the instruments in “Air.” Similarly the space-defining elements of the path inherit the characteristics of the notes, such as the “tone” and “duration,” as well as the association of the notes of the piece to the counterpoint formation (Figure 3).

The spatial boundaries of the pathway are shaped by three sets of space defining elements that correspond to the three distinct “attention groups” of the notes of the piece. In this regard, the notes of the cello determine the placement and dimensions of the space defining elements (concrete paves) on the ground plane. Their placement creates an inner path that make the visitors shift from one side of the pathway to the other. The side elements of the pathway occur from the background notes in each one of the other three instruments. Their characteristics are the long duration and their secondary use inside the musical piece. The side elements of the pathway inherit the characteristics of the background notes.

The remaining notes between the three instruments compose the melody and are the latest and most important series of notes that form the foreground. These notes generate the overhead sheet metal elements that attract the visitors’ attention (Figure 4).
The imprint of the musical piece in the path determines the location of all other elements in the Park such as the harmonographic structures, the secondary routes, the topographic relief of the site, and the areas planted with bushes and trees.

The harmonographic structures, as mentioned earlier, are outdoors semi-covered station areas planned to host or provoke combined music-sound and art events. Their shape follows the logic of the Harmonograph (Ashton, 2003). For the purposes of creating a three-dimensional shape, a harmonographic surface has evolved from the two-dimensional instrument into a three-dimensional structure (Figure 5).

DESIGN ALGORITHMS

To translate a piece of music into a pathway in an architectural context, its most important and “objective” elements had to be selected and analyzed according to their counterpoint and perceptual properties. Certain elements, such as those related to “hue” properties, were intentionally omitted, as they rather entail a subjective understanding and interpretation.

In order to convert the notes to objects, we had first to convert them to numbers. Information with regard to the instrument, length, tone and range of each note was needed to form the parameters of the geometric shapes along the path, and was thus collected on a spreadsheet. This digitation process required filtering and restructuring all music data so that the required information about each note could be received. The new digital data were introduced into algorithmic expressions that allowed us to control all spatial information parametrically. The results of the counterpoint analysis of the piece, along with the constraints that occurred from the application of the Gestalt laws of perception, were also incorporated into the developed algorithms.

In order to generate the spatial geometry of the pathway and the harmonographic structures in a 3D graphical environment, two different design algorithms have been developed. The first one, Algorithm I, generates the path and all the elements that form its spatial definition, such as the ground plane, the overhead plane and the side elements; the other one, Algorithm II, shares data with the previous and generates the geometry of the harmonographic surfaces.

Algorithm I

This first algorithm involves two steps. At the first step the shape and the length of the path is generated. Then the algorithm, together with the music data, takes into consideration site data and constraints, and generates the geometry of all the other space defining elements. The algorithm this time generates three sets of elements, ground, side and overhead. For the generation of the geometry of each one of them, their basic geometry (rectangle, trapezoid, spacing between elements e.t.c.) and their correspondence to the elements of the musical piece were the most important parameters of the algorithmic expression.
In this algorithm, each one of the three space defining elements, that corresponds to an “attention group” incorporates some of the most notable characteristics of the notes, as derived from a Gestalt based analysis, such as their counterpoint formation. Particular cases of implementation of the characteristics of an “attention group” to a set of space defining elements are described in the following paragraphs:

The cello has the typical baroque form of the walking bass line; the cello notes, as already mentioned, determined the placement and shape of the concrete paves on the ground plane. The cello series of notes follows a specific pattern throughout the
musical piece. Each pattern consists of four notes that is repeated according to the following sequence: 1st Note -> +7 Notes -> -1 Note -> -7 Notes, called octave leaps. Each note is translated into a quadrilateral ground element, with a colour saturation index that occurs from the position of the note in the pattern; in this manner the elements of the path are expected to recreate the experience of the cello notes’ pattern. By assigning a length that corresponds to the tone of each note, the above pattern can be noticed in the trace of the path (Figure 6).

The side elements of the music pathway, that serve as informational boards, follow the boundaries of the path while their height depends on the tone of the respective notes. These are placed on the side of the path that corresponds to the instrument from which the notes originated: the Lead Violin notes determine the features of the left side elements of the path, while the second Violin and Viola the right. The objective here was: a) to let the side elements contribute to the balance of the next “attention group,” where the lead Violin has almost half the Foreground notes, and b) to highlight the constant change of roles between the instruments (when the foreground ends the background begins and vice versa).

The last “attention group” is considered the most complex and functional. The purpose this time is to create “aerial”, or overhead elements, that represent the notes of the melody. These are the most important notes of the musical piece, with a wide range of qualitative differences, as, in general, melodies present a great variety of notes (Figure 7).

Each overhead element has a rectangular shape while its origin is placed on the middle line of the path. The overhead elements are placed at different heights from the ground and some of them are titled. Their height corresponds to the importance of the note in the melody, with the most important being the one closest to the ground. As with the side elements, each overhead element is characterized

Figure 8
Placement and shape of the overhead elements corresponding to the melody notes.
by a left or right orientation that corresponds to the instrument, from which the note comes. The length and the slope of the each overhead element is defined by the tone of the note (Figure 7).

Additional parameters of the overhead elements integrated into the algorithm are their height, brightness and colour. Darker shades were given to the elements that correspond to the most important notes that are placed closer to the visitors; a red colour was given to the elements that correspond to notes that are part of a counterpoint formation (Figure 8).

In brief Algorithm I integrates several parameters that derive from the characteristics of the notes in the selected piece, such as their counterpoint formation, frequency, duration, as well as the features of the notes before and after the one examined, and generates the shape and placement of the respective space defining elements on the site.

**ALGORITHM II**

For the creation of the harmonographic structures a 3D interpretation of the basic harmonograph organ was used by extracting the equations that occur from the original organs and making digital modifications to them. The original organ uses two pendulums, the combined motion of which produces 2D drawings that reflect various ratios of the parameters. The ratio derived from the Pythagoras musical scale is found to produce particularly interesting results.

Once Algorithm I has generated the shape of the path and the three sets of space defining elements, additional space elements are created, by placing lines perpendicular to the path that correspond to notes that are scaled according to their proximity to the location of the harmonographic structures. These are converted into ratios according to Pythagoras scale. These ratios, as well as some other characteristics of the site, are then used to generate four different harmonographic structures.
So the Algorithm II that generates the 3D spatial form of the harmonographic surfaces, uses the site data and the data that come from the music piece, already used for the shape and spatial definition of the path. This algorithm generates the geometric configuration of the harmonographic structures in a 3D graphical environment. The algorithm extracts the proportions of each one of the 3D harmonographic structures from the proportions of the notes of the basic path that is nearest to it. Respectively the algorithm generates the geometry of the four harmonographic structures which are named according to their primary function as follows: “Entrance”, “Light and Sound”, “Auditorium”, and “Waterfall” (Figure 9).

CONCLUSIONS
The main objective of this research was to develop a process that permits transferring the basic characteristics of a piece of music into spatial geometry, translating the linearity of time while listening to this piece, to a stroll, or better, a walking journey, along a pathway. This was done by selecting a particular piece, in this instance, the Air from the Suite for Strings in D major of Bach. This piece was used as a source database, which, with the application of the developed algorithms, was converted to an output database of spatial data.

The musical pathway in Park D# provides a spatial experience of Air, the features of which have determined the consecutive stages in the design of the path. At the initial design stage, the parts and phrases of the piece have determined the shape of the path. Then, separating the notes according to their perceptual properties in different categories, by following the principle of similarity in Gestalt, the main space defining elements of the path have been generated. Finally, the differentiation between similar consecutive space defining elements is based on the characteristics of the notes in the piece, such as frequency, duration and association to the piece's counterpoint.

Park D# has not been inspired by music but it is a consistent transfer of a music piece into an architectual space. The developed processes and algorithms can be modified to address different scenarios that involve a music piece and an architectural project.

REFERENCES