

Reciprocal transformations between music and architecture as a real-time supporting mechanism in urban design

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Abstract

The more complex our cities become, the more difficult it is for designers to use traditional tools for understanding and analyzing the inner essence of an eco-system such as the contemporary urban environment. Even many of the recently crafted digital tools fail to address the necessity for a more holistic design approach which captures the virtual and the physical, the immaterial and the material. Handling of massive chunks of information and classification and assessment of diverse data are nowadays more crucial than ever before. We see a significant potential in combining the fields of composition in music and architecture through the use of information technology. Merging the two fields has the intense potential to release new, innovative tools for urban designers. This article describes an innovative tool developed at the Technical University of Crete, through which an urban designer can work on the music transcription of a specific urban environment applying music compositional rules and filters in order to identify discordant entities, highlight imbalanced parts, and make design corrections. Our cities can be tuned.

Keywords

Urban design, design creativity, translation, music, architecture, city modeling

Introduction

We live in a time of scientific visualization and, increasingly, sonification, where we find that other, neglected, sensory pathways allow us to understand this world more fully and immediately than the conventional, numerical, calculated way we have inherited. We know that a screenful of information makes patterns accessible to us in ways that a list of numbers cannot and that the sound of a formula reveals intricacies of behavior that the symbolic or pictorial representations obscure.¹

The cognitive process of analyzing today's chaotic urban eco-system can be augmented in real time by employing cross-modal understanding and intervening through the eco-system's musical footprint. Based on a grammar which connects musical elements with architectural elements, we present a system that offers

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sonification of an urban virtual environment (UVE), simulating a real-world cityscape and offering visual interpretation and interactive modification of its soundscape in real time.

Background

“Markos Novak invents the term *archimusic*, in order to describe the art and science that results from the conflation of architecture to music, and is to visualization as knowledge is to information.” In the context of cyberspace and artificial nature, Novak makes a distinction between the *archimusic within information* and the *archimusic of information*:

Archimusic within information is architecture and music combined and extended to exist within virtual worlds, but still investigating the preoccupations of our familiar worlds. Archimusic of information is the architecture and music that is directly implicit in the artificial nature of cyberspace.

Novak’s notion that architecture and music are freed from their limitations to matter and sound, respectively, is in reference to Iannis Xenakis’² view of music “inside-time” and music “outside-time,” as presented in his book *Formalized Music*. The dual proficiency of Xenakis in the fields of music and architecture, as well as his collaboration with Le Corbusier, led to explorations and innovations in composing in space and time. Famous examples include the *Philips Pavilion* for Expo 1958 in Brussels and the design and construction of the monastery *Sainte Marie de la Tourette*. The Philips Pavilion, by Xenakis and Le Corbusier, consisted of nine hyperbolic paraboloids instead of flat surfaces, and the music was spatialized (Figure 1). Thus, the concept of virtual and real space emerged. As basis for the design of the pavilion, Xenakis used his work *Metastasis*, which was based on the designs and mathematical proportions given by Le Corbusier’s *Modulor*, in order to compose the micro- and macrostructure of the piece in time.³ The overall structure and the control of elements, such as the massive glissandi, resulted in the idea of the hyperbolic paraboloids used in the pavilion. In the monastery of *La Tourette*, Xenakis’ detailed work on rhythm proved crucial in designing the undulating panes of the facade. This was achieved by interpreting them in terms of the density of the inner structure of the panes, thus achieving a contrapuntal texture.⁴

Despite the fact that we often think of architecture as material and music as immaterial, we should reconsider the relationship of these two sister arts through a more holistic approach, liberating them from the strict blinders that Western civilization has endowed us. The challenge is to embrace the concept that architecture can lie beyond buildings and music beyond sound.

Methodology

The methodology analyzed in this article expands the hearing experience of the urban environment by marking its basic spatial elements and transforming them to sounds. Using the philosophy behind Xenakis’ UPIC (Unité Polyagogique Informatique CEMAMu) system as a starting point, we have developed a translation method according to which geometrical data are translated to sounds. Street facades, the fundamental imprint of our urban environment, are first broken down to their main semantic elements. These elements have properties, such as position and size in a three-dimensional (3D) (XYZ) system, which are transcribed into sonic data: length in X axis is mapped to note appearance in time and note duration (tempo), height in Y axis is mapped to note value (pitch), and depth in Z axis is mapped to volume (Figure 2).⁵ Different elements correspond to different timbre and voids to pauses (silence). Another mapping on which we are currently working on is the correlation of color to sound.

The research is based on the theoretical and practical work (installations) of Iannis Xenakis along with the mathematical reasoning behind it. Mappings have been following the philosophy behind Xenakis’ UPIC

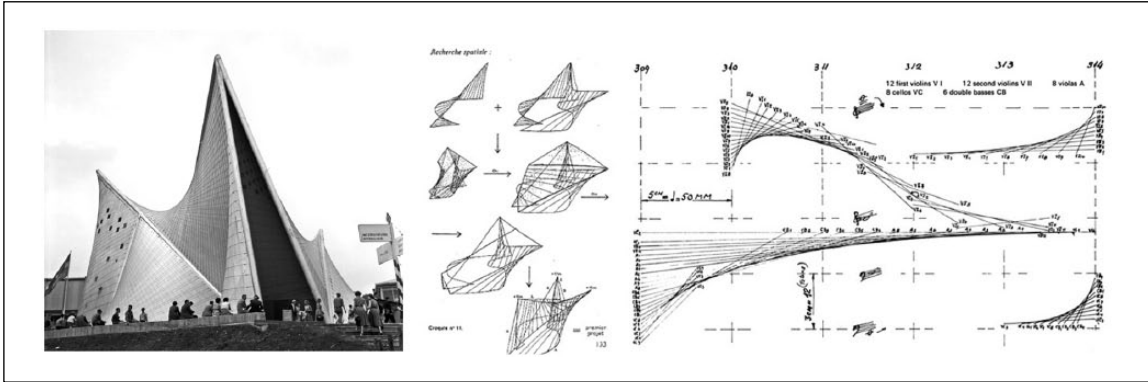


Figure 1. Philips Pavilion/Metastaseis B, Iannis Xenakis (1953–1958).

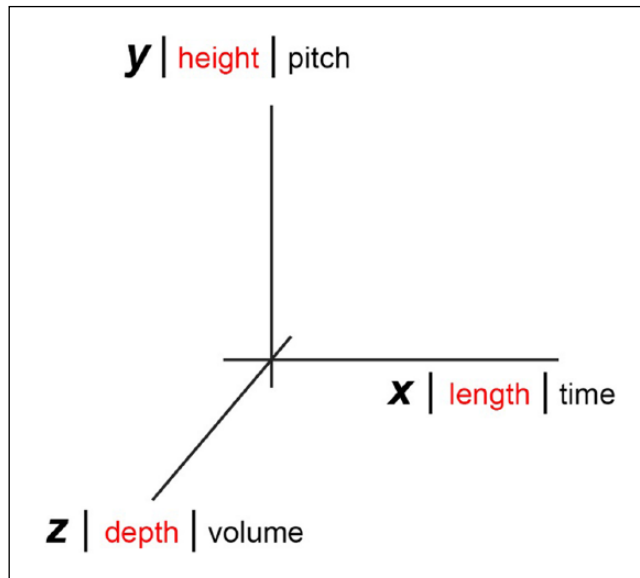


Figure 2. Translation concept.

system, which serves as the basis for the selection of the X and Y axes and their corresponding mapping. Selection of urban elements to be translated have been taking into account the theoretical work of Kevin Lynch,⁶ who has underlined paths, edges, districts, nodes, and landmarks, as the most important urban element when identifying a city.

Any given path of an urban setup can be marked in order to create its soundscape with sounds produced by selected musical instruments. A simulation of an urban environment is created including urban elements fundamental for “reading.” These are buildings, paths, gaps, stairs, and so on. Building blocks are provided by the system and external elements can be included. Once the environment is assembled, the user can choose an urban path to translate to sound. The path is then scanned from the starting to the ending edge and the sound representation of the elements on that path is saved in an MIDI (Musical Instrument Digital

Interface) file. The system utilizes the MIDI protocol to communicate between the graphical representation of the urban environment (a facade of the street, square, and so on is first transcribed to music score) and the acoustic output. The acoustic output, modified according to selected music composition rules and filters,⁷ follows the reverse process to be translated back to a new, refined urban environment. The result is a more balanced, tuned, built environment without reluctant pieces.

Implementation

Supported functionality

The application supports four major functionalities. These are file manipulations, view, scene composition, and generating sound from selected architectural elements. The file manipulation options allow one to create a new scene where the urban environment will be composed, to open already created scenes, and to save the current scene on the file system. The user can set many different viewing options under the view options. These include showing and hiding the grid, show/hide sky which is used to give the feeling of a real world to the scene. Other preferences are to set color for the background and the remaining view option is to set up an image, a map of some town, for example, to the floor in order to create specific urban environment on which different architectural elements could be positioned. Other major category is the scene composing tools that were created in order to edit the environment. These are the tools that enable one to move the elements around, to scale them to the size he or she wants, and to rotate them in three axes. One of the two remaining functionalities (in the time of writing) is the ability to generate sound from a “sound” path. More specifically, the user creates a line by selecting different points on the map, and when it’s done, the line is scanned and the elements are played. The second is loading MIDI file and generating architecture elements from it.

Graphical user interface

We differentiate four main areas: The *Main menu*, the *Architectural elements*, the *Transform tools* and the *Main area* (Figure 3). The main menu provides common functionality such as open/save scenes, change the editor view settings, as well as translate architecture to music and vice versa. The architectural elements found on the left side are the base building blocks of the 3D environment. The transformation tools are used for editing the 3D world. Supported manipulations include translation, scale, and rotation. The user is able to construct the urban environment.

Architecture to music—music to architecture

MIDI protocol. The sound is generated and stored using the MIDI protocol which can carry up to 16 channels of information. The notes are MIDI messages and are expressed through note number for different octaves. There are 128 (0–127) note values (~11 octaves) mapped to the Western music scale. As a base octave, we chose the fifth octave because the lower octaves of low frequency prohibit perceptible sound differentiation between distinct elements.

Translation/mapping. The application supports five types of architectural elements utilized to build a UVE and consequently for generating sound. These elements are “Building,” “Opening,” “Shelter,” “Roof,” and “Tree.” One can use these elements to build complex urban environments which can be transformed to a sound. These elements are 3D shapes and as such have the following properties: height, length, and depth. The properties take values from the set of real numbers.⁸

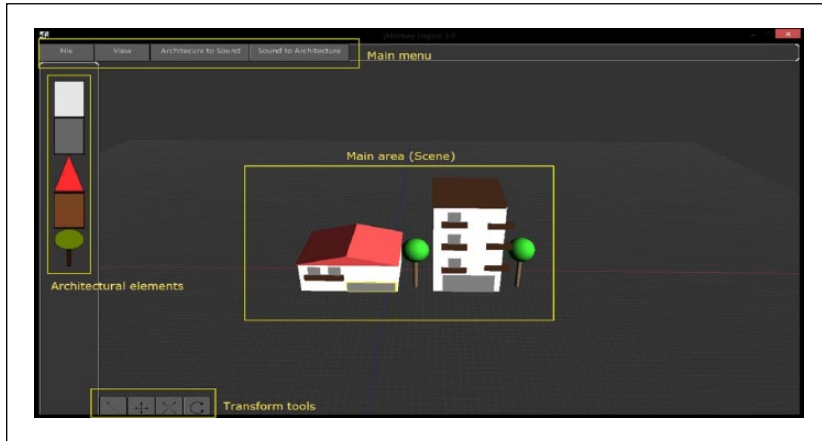


Figure 3. The application's graphical user interface.



Figure 4. Translation.

We translate element's height to note value (pitch), element's length to note duration (time), and element's depth (position in Z axis) to volume. As a basic unit for mapping, height to note value is the "FLOOR" on which the element is located. The floor is considered to be 3 m high. The first floor is mapped to C (5th octave), the second to D, the third to E, and so on. As for the length, 1 m is mapped to 1 s note duration. For example, if we have a building that is 10 m high and 15 m long, it would be translated to the F note (5th octave) with a duration of 15 s. Respectively, a floor or a balcony that is protruding will sound more intense and one that is recessed will have a lower volume, thus mapping the perception that it is further away (Figure 4).

The notes take values from C—major scale which is the most common key signature in the Western music. In order to map architecture to music, the user specifies paths (lines) in the scene that he or she wants to hear. The sound imprint of the selected elements in the virtual environment (VE) is created by scanning the path in which they are located. As the scanning progresses, the notes and sound parameters that represent



Figure 5. Translation of Naples' facade to sounds—physical environment.

the path's architectural elements are written as MIDI messages in an MIDI file. Every type of architectural elements is mapped to a different channel in the MIDI file and is played by a different music instrument. Then, the file is opened in an MIDI editor for modifying, and the architectural impact on the scanned path is visible in real time (Figures 5–7).



Figure 6. Translation of Naples' facade to sounds—virtual environment.

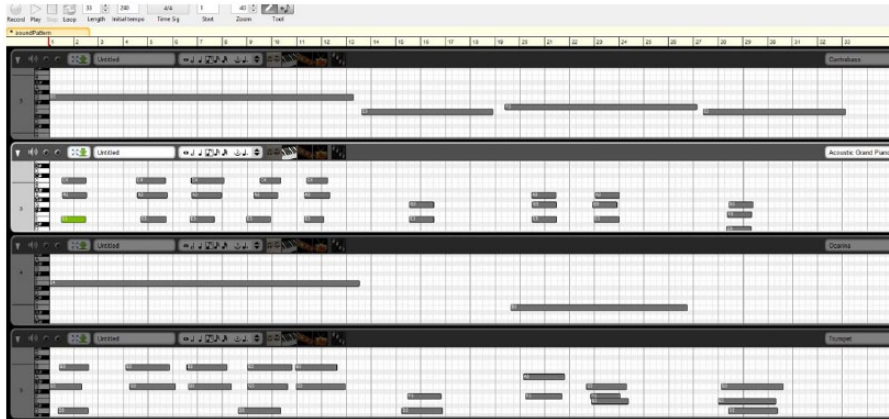


Figure 7. Translation of Naples' facade to sounds—music imprint.

The application also supports the reverse translation: music to architecture. This is achieved using the channel information of the music score and the time to spatial relationship that exists between notes and elements. First, a well-formed MIDI file (i.e. file that complies with the structure defined by the application) needs to be loaded into the program. The loaded file is processed (with JFugue library) and sound string is constructed. Next, the string object is parsed using rules that are exactly opposite of the architecture-to-sound translation. Based on the channel or instrument information, buildings, openings, and other architecture elements are created, and based on the note value, duration and volume, the height, length, and depth are set. The algorithm can be explained as follows: first, find the channel that the notes belong to in order to find the architectural group and then scan the channel from left to right to match the beginning and the ending of the sound path.

The reverse process has not been completed yet, it is currently being developed. The technical aspect of it is already in place, but there are steps on the translation method that have to be completed first in order to

have a fully functional tool that would make sense. The proposed method needs to be tested in specific case studies (take certain streets from different cities and translate them into sounds) in order to calibrate the system and validate the method. These case studies can be followed by a series of surveys in order to get feedback from citizens on issues like harmony, beauty, and tense, as well as on which version of the facade they prefer.

Having the ability to edit the acoustic imprint of an urban environment and experiment with different music composition rules and filters provides urban designers an extended, augmented, cognition level for tuning the result and eliminating discordant elements.

Software stack

The application was built with the Java programming language. Java is a language for developing cross-platform desktop applications and provides a very rich application programming interface (API) right out of the box. The reasons for choosing Java were vast amount of third-party libraries, full documentation available, excellent performance (even for graphics), garbage collection, and many more features.

We used the jMonkey Engine (jME) game engine for the development of the application. jME is written in Java and uses Lightweight Java Game Library (LWJGL) as its default renderer; it is completely free and open source, thus allowing to add or change functionalities at very low level. It is a collection of libraries, making it a low-level game development tool. It comes with NetBeans IDE, thus allowing us to gain access to higher level tools that enhance building large 3D applications.

For the MIDI programming, we used JFugue. JFugue is an open-source programming library that allows one to program music in the Java programming language without the complexities of MIDI. The main advantage of JFugue is its simplicity; it allows one to specify music by writing strings like "C D E F G." The main features of jFugue are microtonal music, music patterns, rhythms, interaction with other music tools and formats, read or write musical data from MIDI, and so on. Another important aspect of JFugue is that it allows creating music at runtime.

The protocol used to communicate between the 3D urban environment and its sound representation is the MIDI protocol. MIDI provides an in-depth analysis of the characteristics of the generated sound, such as the note, the note's pitch, the velocity, and the channel number.

Conclusion and future work

In the past century, we have witnessed a transformation of the artist from craftsperson to composer to editor; now we can take the next step, the artist seen as decoder of mysterious signs seen as streams of data. If an appropriate way of reading the data can be invented, a work of art, a work of revelation, will follow, otherwise, noise.¹

Acoustic data decoded from the built environment provide a valuable platform on which discordant entities can be more easily identified and also imbalanced parts get highlighted. It is obvious that different translation methods can be picked, for example, with different mappings on the axes, but our research team has selected to focus on the work of Iannis Xenakis and try to further develop his translation vocabulary. Our proposed methodology and consequent tool need calibration and validation in order to become useful as a real-time compositional tool in urban design.

The software platform supporting this work could be extended to include viewpoint variability, photorealistic rendering, as well as interactive manipulation of imagery and sounds produced or vice versa. The explosion of virtual/augmented reality as well as gesture-based and vision-based interfaces could incorporate the architect's body in the interaction, resulting in an immersive visual and acoustic environment where the user will be able to alter the architecture as well as the sound grammar interactively. The affordances put

forward today integrating the physical and the digital could provide opportunities for superimposing design ideas on existing architecture and concurrently “composing” the design of architectural features through cross-modal sound design. The software may also be ported on mobile platforms incorporating social communication by crowdsourcing user views as well as a multitude of test cases across the globe, culturally and architecturally diverse.

By highlighting the strong inner values and relationships between the prime particles of an urban eco-system and by eliminating the alien interferences, we provide valuable tools to assist designers in preserving the eco-systems viability and originality. Cities can be tuned. Furthermore, this eco-systemic methodology has the potential to reveal key patterns, not visible to the human eye, which can then be further analyzed and reused in attempts to create new eco-systems from scratch.

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