

Reciprocal Transformations between Music and Architecture as a Real-Time Supporting Mechanism in Urban Design

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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, classification and assessment of diverse data is 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 paper 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, 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.

(Novak 2007)

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 with architectural elements, we present a system that offers sonification of an Urban Virtual Environment (UVE), simulating a real-world cityscape, offering visual interpretation and interactive modification of its

soundscape in real time.

ARCHIMUSIC

Markos Novak invents the term archimusic, in order to describe the art and science that results from the conflation of architecture to music; archimusic - a place where buildings can flow and music can be inhabited- is to visualization as knowledge is to information. 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 blinkers that western civilization has endowed us. The challenge is to understand that there is architecture beyond buildings as there is music beyond sounds.

METHODOLOGY

The methodology analyzed in this paper 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 system as a starting point, we have developed a translation method according to which geometrical data is 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 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 1). Different elements correspond to different timbre and voids to pauses (silence). Another mapping on which we are currently working on is the correlation of colour to sound.

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 etc. 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 a 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, etc. is first transcribed to music score) and the acoustic output. The acoustic output, modified according to selected music composition rules and filters, 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.

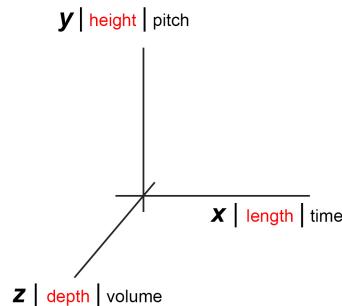


Figure 1
Translation Concept

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 the user 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 different viewing options under the view options menu. These include showing and hiding the grid, changing the background colour, show/hide the sky inducing the feeling of the

real world to the scene. A map of part of a city can be uploaded and used as the floor plan in order to create a specific urban environment of a city's area on which diverse architectural elements could be positioned.

The user could employ the scene composing tools so that the environment is edited. These are the tools that enable the user to move the architectural elements around, to scale them to the required size and to rotate them in three axes. One of the most significant functionalities of the application is the ability to generate sound from a "sound" path. More specifically, the user creates a path by selecting different points on the map. The system scans the path and the architectural elements are 'played' according to the grammar implemented. In reverse, a midi file can be loaded and the associated sound elements could be translated to a specific cityscape.

Graphics User Interface (GUI)

We differentiate four main areas of the Graphical User Interface: The Main menu, the Architectural elements

area, the Transform tools and the Main area. The Main menu provides standard functionality such as open/save scenes, change the editor view settings as well as a translating Architecture to Music and vice versa. The Architectural elements area located on the left side of the application provide the basic 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 now able to construct the urban environment (Figure 2).

Architecture to Music - Music to Architecture

MIDI protocol. The sound is generated and stored by using the MIDI protocol which can store up to 16 channels of information. The notes are represented in the form of MIDI messages and are expressed through note numbers associated to different octaves. There are 128 (0-127) note values (~11 octaves) mapped to the western music scale. As a base octave we selected the fifth octave because the

Figure 2
The application's
graphical user
interface

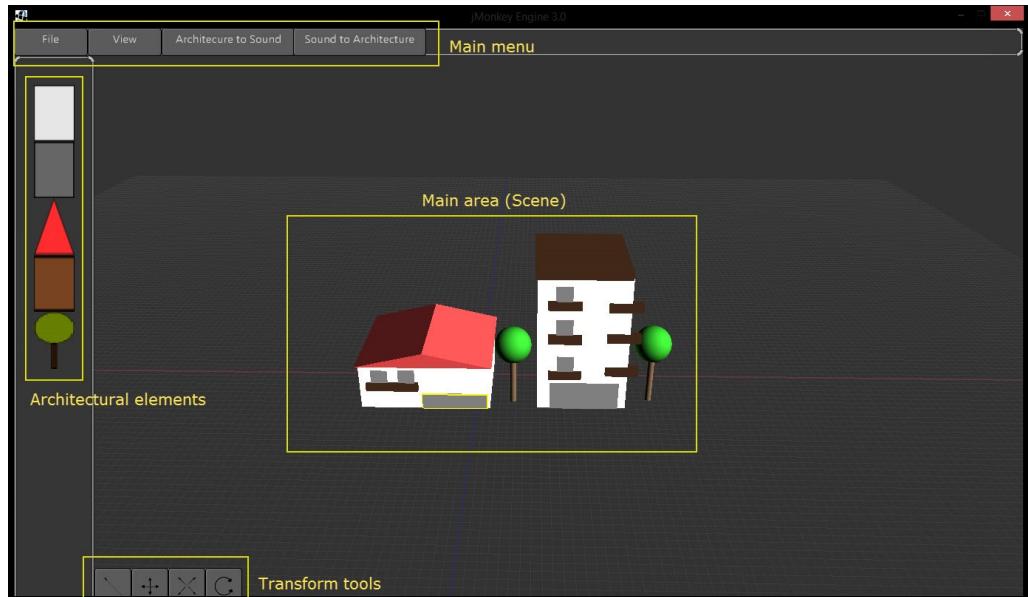
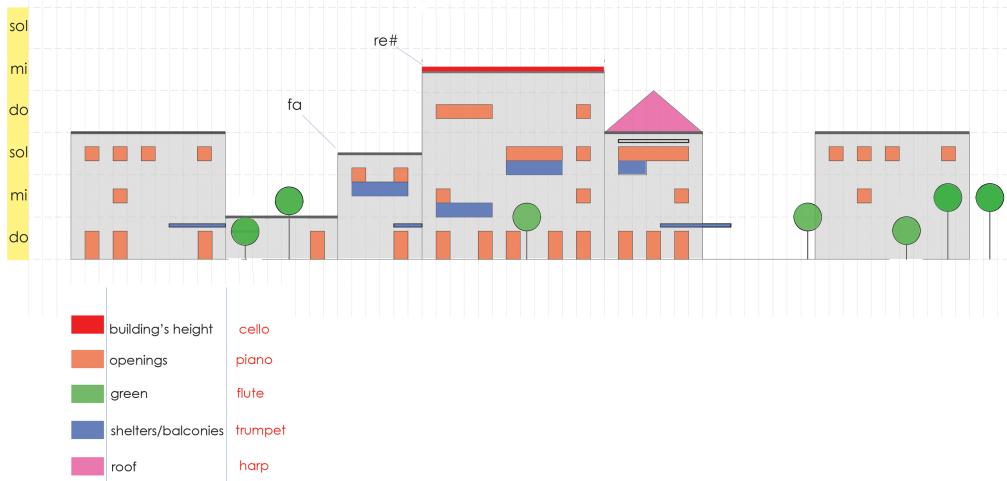


Figure 3
Translation



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.

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 meters 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, one meter is mapped to one second note duration. For example, if a building is 10 meters high and 15 meters long, it will

be translated to the F note (5th octave) with a duration of 15 seconds. Respectively, a floor or a balcony that is protruding will sound more intense and one that is recessed will have a lower volume, thus communicating that it is further away. The different elements are mapped to different instruments (timbre) and voids to pause (silence) (Figure 3).

The notes take values from the 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 to be heard. The sound imprint of the selected elements in the VE is created by scanning the path in which they are located. As the scanning progresses, the notes and sound parameters that represent the path's architectural elements are written as MIDI messages in a MIDI file. Every type of architectural element is mapped to a different channel in the MIDI file and is played by a different music instrument. Then, the file is opened in a MIDI editor for modifying and the architectural impact on the scanned path is visible in real time (Figures 4,5,6).

Figure 4
Translation of
Naples's facade to
sounds – Physical
Environment



Via Salvator Rosa, Naples - Google Earth Street View

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

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, awareness at the cognitive level so that the final architectural result is tuned by eliminating discordant elements.

Software stack

The application was built employing the Java programming language. Java is a language for developing cross-platform desktop applications and provides a very rich API. The Java programming language encompasses a vast amount of 3rd party libraries. Complete and detailed documentation is available, garbage collection and many useful features resulting in excellent performance, even for the computationally heavy computer graphics scenes.

We used the jMonkeyEngine (jME) game engine for the development of the application. jMonkeyEngine is written in Java and uses LWJGL as its default renderer. It is completely free and open source, thus, allowing the developer to add or change functionalities at a very low level. jME comprises of a collection of programming libraries, therefore, it is a low-level game development tool. It comes with NetBeans IDE, thus, allows the developer to gain access to higher level programming tools supporting the implementation of complex 3D applications.

The protocol employed so that the 3D urban environment communicates with its sound representation is the MIDI protocol. MIDI provides an in-depth analysis of the characteristics of the generated

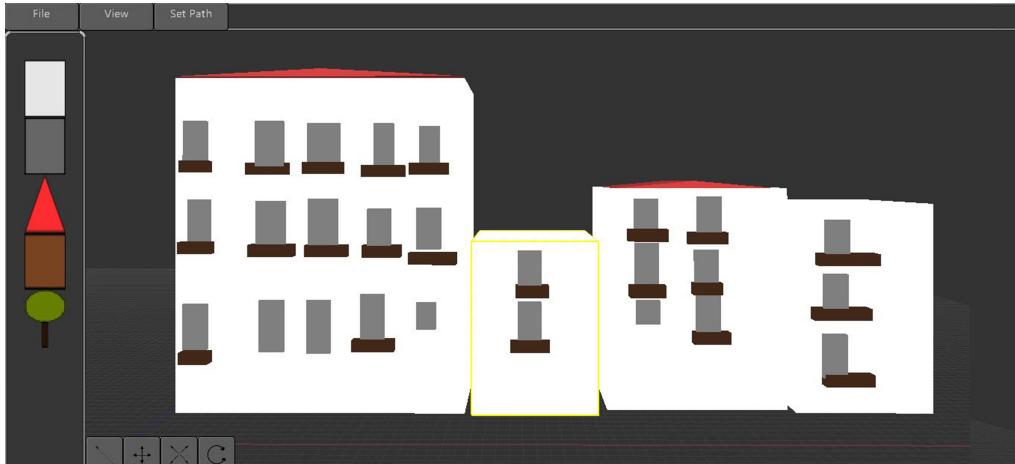


Figure 5
Translation of
Naples's facade to
sounds – Virtual
Environment

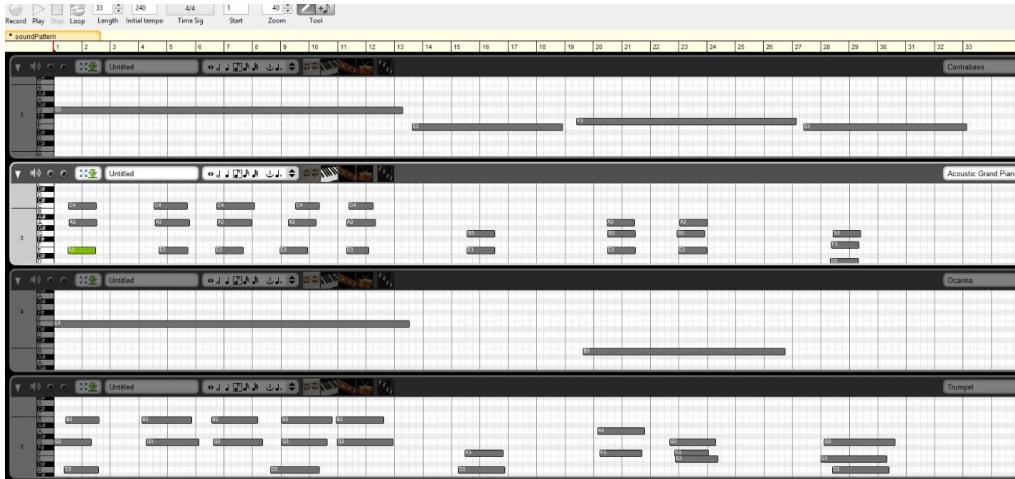


Figure 6
Translation of
Naples's facade to
sounds - Music
Imprint

sound, such as, the note, the note's pitch, the velocity and the channel number.

In relation to MIDI programming, the JFugue platform was employed. JFugue is an open source programming library allowing to program musical elements in the Java programming language without the complexities of MIDI. The main advantage of JFugue is its simplicity. It allows the developer to specify music by writing strings such as the following: "C D E F G". The main features of jFugue are microtonal music, music patterns, rhythms, interaction with other musical tools and formats as well as reading or writing musical data from MIDI etc. Another significant aspect of JFugue is that it allows the creation of music at runtime.

CONCLUSION & FUTURE WORK

In the past century we have witnessed a transformation of the artist from craftsman 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. (Novak 2007)

Acoustic data decoded from the built environment provides a valuable platform on which discordant entities can be more easily identified and also imbalanced parts get highlighted. There is great potential in using a real-time translation method as a composition tool in urban design, especially when exploiting its integrated feedback features. 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 re-used in attempts to create new eco-systems from scratch.

ACKNOWLEDGMENT

The work of Katerina Mania has been supported by the THALES project (CYBERSENSORS - High Frequency Monitoring System for Integrated Water Resources Management of Rivers). The project has been co-financed by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - THALES. Investing in knowledge society through the European Social Fund.

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