ARCHIMUSIC3D: Multimodal Playful Transformations between Music and Refined Urban Architectural Design

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***Abstract*—The commonly used 3D architectural design tools for urban environments fail to capture aspects of an urban design which are aesthetic as well as functional. This paper describes an innovative multimodal user interface 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. The proposed platform offers sonification of an Urban Virtual Environment (UVE), simulating a real-world cityscape, offering visual interpretation and musically playful modification of its soundscape. The system presented offers: The ability to view and convert an urban street to music (ready to play) based on a specific grammar of converting architectural elements to musical elements; secondly, the ability to transform this music in order to 'harmonize' it based on musical rules as if composing and playing music; and finally, the prospect of converting back the aesthetically and harmonically "corrected" musical piece to a newly refined street or urban design, visualized in 3D. The presented platform comprises of three scenes, which compile the three main parts of the system's multimodal interface; e.g., the 3D scene, the Digital Audio Workstation (DAW) scene and the TouchOSC mobile controller. The purpose of this paper is to assist architects and urban designers in 1) identifying urban dissonances, 2) refining their design using musical rules and 3) interactively presenting the output both visually and acoustically.**

***Index Terms*—multimodal, 3D graphics, music, urban design**

I. Introduction

An urban designer requires advanced digital tools in order to design the inner-relations and functions that describe contemporary cities. The current image of cities is not the result of a single, coherent, decision making process [1]. The commonly used 3D digitally-crafted architectural design tools for urban environments fail to capture the aesthetic as well as functional aspects of an urban design as they are merely descriptive of the geometrical composition of a space [2]. This also applies to design platforms based on gamified scenarios in the context of urban mass housing design, involving multiple stakeholders, which mainly focuses on visual spatial design [3], [4]. Multimodal interaction in architectural design is often limited to speech recognition [5], [6]. There is significant potential in combining the fields of composition in music and architecture through the use of interactive 3D graphics, uncovering aspects of an urban design not apparent based on the standard, vision-based digital design tools [7], [8].

This paper describes a highly innovative multimodal 3D user interface through which an urban designer can formulate the musical 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. The 3D multimodal platform presented offers sonification of an urban Virtual Environment (UVE), simulating a real-world cityscape and visual interpretation and interactive modification of its soundscape. The system presented offers: The ability to view and convert an urban street to music (ready to play) based on a specific grammar of converting architectural elements to musical elements; secondly, the ability to playfully and interactively transform this music in order to 'harmonize' it based on musical rules; finally, the prospect of converting back the aesthetically and harmonically 'corrected' musical piece to a newly 3D refined street or urban design. In this work, for the first time, the cognitive process of analyzing today's chaotic urban ecosystem is augmented with the new dimension of understanding but also intervening through its musical footprint.

Urban planners and architects are interested in finding ways to effectively represent the "reading" of the city [9]. Markos Novak [10] invents the term 'archimusic', in order to describe the art and science that results from the conflation of architecture to music. 'Archimusic' includes architecture and music combined extended to exist within virtual worlds. Novak's notion that architecture and music are freed from their limitations of matter and sound, respectively, is in reference to Iannis Xenakis' view of music "inside-time" and music "outside-time," as presented in his book 'Formalized Music' [11]. 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.

II. Description

The presented multimodal platform for urban design named Archimusic3D comprises of three scenes, which compile the three main parts of the system's multimodal interface; e.g., the 3D scene, the Digital Audio Workstation (DAW) scene and the TouchOsc mobile controller (Figure 1 upper and lower part respectively). While interacting with the 3D scene, the user is able to navigate a 3D street in order to observe the 3D graphical depiction of an urban environment (Figure 3). The second scene is the implementation of a Digital Audio Workstation (DAW) program, in which the user is able to manipulate the musical footprint of the street printed as a MIDI (Musical Instrument Digital Interface) file in order to listen to it and process it (Figure 4). Processing is conducted via a third tool representing a TouchOsc mobile controller, which is a virtual mobile console containing faders, potentiometers and buttons (Figure 1 below). When users convert the 3D scene to a musical footprint, they can also subsequently submit the reciprocal transformations which may be applied to the musical part as if playing and composing music. Then, they are able to navigate a newly refined, visualized street.

III. Translation

At first look, music and architecture seem unrelated, but they share features, which relate to both architectural and musical composition [10]. The first step is to match the parameters and architectural elements of the urban eco-system to those of its musical footprint [12]. Based on a specific grammar, musical and architectural elements are connected [10], [13]. The result of translating architectural elements to sounds forms the musical footprint of a street. The basic rules for this translation are: the height of an element is translated to the pitch of a note, the length of the element is translated to the duration of the note and the depth of the element is translated to the volume of the note. The piano is associated with a window, the flute with a tree, the xylophone with a balcony, the bass with a door, the cello with a building and the violin with a larger scale building. The definition of these transformations are by themselves challenging and open to discussion. In this paper, we define an initial simplified grammar of architecture-to-music translations as explained above. This is open to future extensions so that all elements of an actual, complex environment are included.

While users interact with the second scene representing an implementation of a Digital Audio Workstation (DAW) program, they can play and stop the sounds of the musical footprint, select and modify musical parameters such as the time, the volume and the pitch of any instrument's note. When the user selects and modifies a note, the transformations of the musical parameters of this note are translated, in real-time, to transformations of the architectural parameters of the corresponding 3D object. Furthermore, the user has the ability to add a new note played by any music instrument and a corresponding 3D object representing an architectural element is added.

Having the ability to playfully edit the acoustic imprint of an urban environment, as if playing and composing a musical piece and experiment with music composition rules and filters, provides urban designers an extended, augmented, multimodal cognition level for tuning the design process, eliminating discordant elements. The result of this multimodal processing is a new elegant song and at the same time a newly 'refined' 3D urban street.

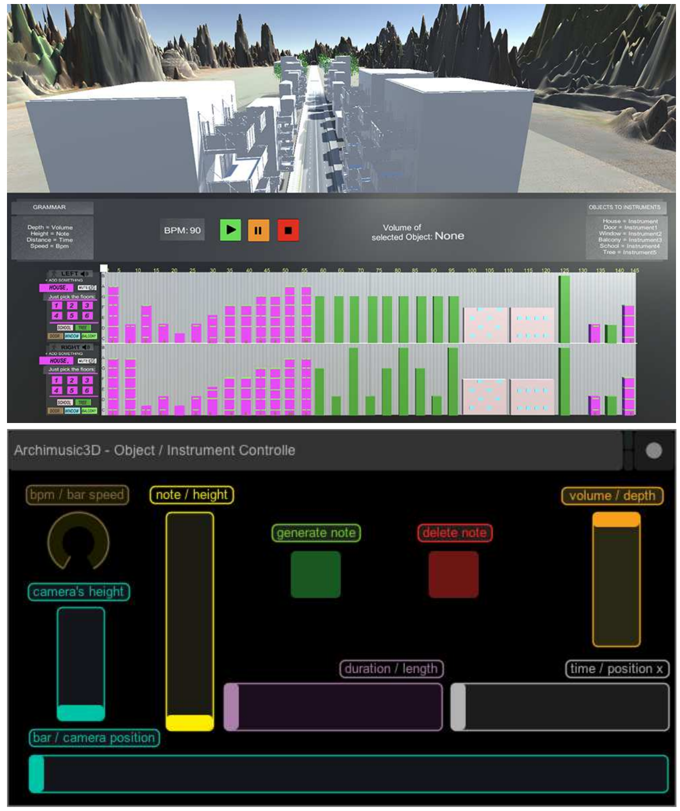

Fig. 1. Archimusic3D: the complete platform

IV. 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 musical composition tools (UPIC) system as a starting point, a translation method is developed according to which geometrical data is translated to sounds [13]. Street facades, the fundamental imprint of the 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 as shown in Figure 2: length in the X-axis is mapped to note appearance in time and note duration (tempo), height in the Y-axis is mapped to note value (pitch) and depth in the Z-axis is mapped to volume (Figure 2). Different elements correspond to different timbre and voids to pauses (silence).

The objects, such as buildings, which make up an urban street, are converted to notes played by musical instruments, such as the piano, which make up a music song and conversely. 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

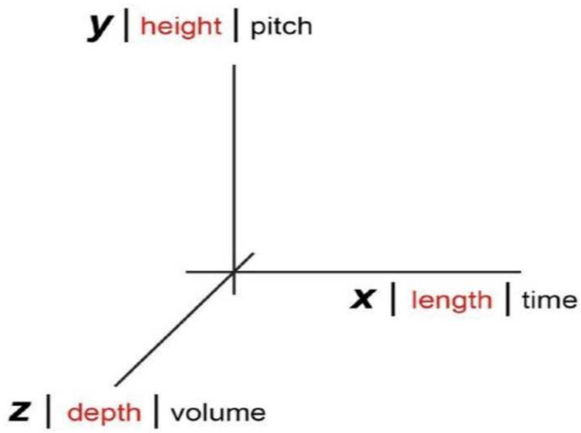

Fig. 2. Methodology

created including urban elements fundamental for ”reading”. Building blocks are provided by the system and external elements can be included.

The application supports six types of architectural elements utilized to build a UVE and, consequently, for generating sound. These elements are ”Buildings”, ”Larger Scale Buildings”, ”Windows”, ”Balconies”, ”Doors” and ”Trees”. One can use these elements to build complex urban environments including architectural elements which can be translated to a sound. In this paper, the conversion grammar associates the piano with the window, the flute with the tree, the xylophone with the balcony, the bass with the door, the cello with the building and the violin with the larger scale building. These elements are 3D shapes and as such have the following properties: height, length and depth. As a basic unit for mapping, height to note value is the ”FLOOR” on which the object is located. The floor is considered to be 3 m high. The first floor of a high rise building is mapped to C, the second to D, the third to E, and so on. As for the length, 1 m is mapped to 1 sec note duration. For example, a building that is 10 m high and 15 m long would be translated to the F note with a duration of 15 secs. Respectively, a building 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.

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 hear. The sound imprint of the selected objects 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 the path’s architectural objects are written as MIDI messages in a simulation of a MIDI file. Every type of architectural object is mapped to a channel in the MIDI file and is played by a different music instrument. Then, the file is opened in an MIDI editor for playful modifications and the architectural impact of the scanned path is visible in real time.

The platform 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 3D objects. 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 type of instrument that the notes belongs to in order to find the respective architectural group and then scan the MIDI file from left to right to match the beginning and the ending of the sound path.

Since in most cases the current image of our cities is not the result of a single, coherent, decision making process, there is an opportunity with the proposed methodology to apply meaning to chaos: in other words, to design. By highlighting the strong inner values and relationships between the prime particles (atoms, bits and notes) of an eco-system and by eliminating the alien interferences, this platform provides valuable tools to assist designers in preserving the eco-systems viability and originality. 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.

Fig. 3. Street View

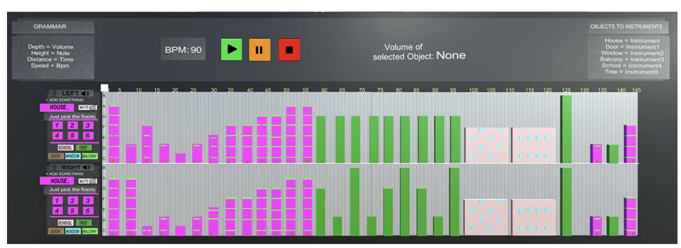

Fig. 4. Daw Program View

V. Evaluation

In order to understand whether the proposed multimodal platform provides a reliable simulation of a DAW program, expert sound designers based at the Department of Music Technology and Acoustics engineering of the Technological Educational Institute of Crete, were invited to evaluate Archimusic3D. A lead architect of the School of Architecture, Technical University of Crete, also evaluated the proposed platform. Experts, together with an instructor, used the system for several hours, in order to convert an urban facade which resembled an actual city street to music. The musical piece created was then musically 'improved'. The resulting music was converted back to a refined urban facade, including more trees and an abstracted architectural design. Their comments are listed here, in summary.

A. Advantages

- The platform proved to be a successful simulation of a DAW program. It provided most of the standard functions of a professional DAW program such as play, pause, stop, mute left and right speaker, bpm play-bar, MIDI protocol, OSC protocol.
- The TouchOSC mobile application provided most of the basic functions that a professional sound processing console provides such as fast real-time response and transformations' precision.
- Notes' transformations functioned accurately. When the musical axes of a note were modified, this new note sounded as the actual note would sound, if played by the musical instrument that produced it.

B. Disadvantages

- The notes were played even if the play-bar was over them although the system was in stop or pause mode. The notes should have been heard only when the play-bar was over them in motion. Furthermore, when a note stoped, a "click" noise sound was heard.
- It was not visible whether the mute button was switched on or off, which means that there is a need for an indication of the mute button's status in relation to whether it is enabled or not, such as the existence of a Volume Unit (VU) serving as a sound intensity indicator.
- When a note was being played at the same time the user modified its pitch, the note remained the same as it was before its pitch was modified. The new note is heard during the next play of this note. The user could no select more than one note at a single transformation.

VI. Conclusions and Future Work

This paper puts forward an innovative multimodal design tool 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 improvements. It implements reciprocal transformations between music and architecture for compositional playful experiments in order to assist urban designers in 1) identifying urban dissonances, 2) refining their design using musical rules and 3) presenting the output both visually and acoustically.

Future work could include the ability to import any architectural element (in .fbx format), created in a 3D graphics design software implementing the Building Information Model (BIK) such as REVIT, or created by a designer as a 3D asset. Respectively, a musical piece can be composed and played employing a variety of musical instruments instead of the demonstrated six musical instruments included. Different conversion grammars could be tested. The capability of exporting the new refined urban street in .fbx format commonly used by architectural design tools programs as well as the final corresponding musical pieces in .wav, .mp3, .mp4 format, commonly used by media players, would be useful. Many of the aforementioned issues could be solved if instead of including the simulation of the DAW program as implemented in Archimusic3D, the platform was connected to an already existing professional DAW program such as Ableton or, even better, if it was possible for the platform to be connected with any professional DAW program.

The creation of an entire urban city consisting of a combination of urban streets and open spaces and a corresponding long-duration musical footprint of an entire city would offer a multitude of composition possibilities. The user could select desired paths through the city for translation and, ultimately, urban design in a large scale.

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