‘HARMONIELEHRE’ FOR ARCHITECTS

Exploring the relationship between music and architecture by scripting

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Abstract. This paper reports on an introductory scripting class that, whilst teaching the basics of algorithmic design to a large number of architecture students, also explored the commonalities between architecture and music. Historical and recent precedents as well as the theoretical and the practical aspect of the project and its pedagogical outcomes are discussed. The technical section includes a detailed description of the setup created for the students. The musical data format used was MIDI (Musical Instrument Digital Interface), which was read into the 3D computer graphics package MAYA and turned into 3D geometries using the scripting language MEL (Maya Embedded Language). The paper also discusses the resulting student works and in how far the musical nature of the data is visible in them.

Keywords. Computational Design Education; Generative & Algorithmic Design; Scripting; Architecture and Music; MIDI.

1. Introduction

In a thinkpiece from 2013 in the Architectural Review, Charles Jencks writes: “As abstract art forms based on rhythm, proportion and harmony, architecture and music share a clear cultural lineage. Now, through digital expression, architecture can attain new heights of creative supremacy.” (Jencks, 2013)

Jencks never makes it very clear what exactly he means by digital expression, but he seems to suggest that it is only available to architecture. It is certainly true that digital computation opens up new ways to explore the relationship between architecture and music. But arguably this is the case because both fields have entered the digital era. Just as digital media today play a key role in the design and construction of architecture, the same can be said about the composition and production of contemporary music. The common ground between these two, in Jencks’ words ‘abstract art forms’ has expanded through the fact that they now also share the abstraction of digital encoding.

This new dynamic in the relationship between architecture and music, as well as an amateur interest in music on the side of the instructors in our Digital Methods of Design teaching team, were the basis upon which we set out to develop the “Harmonielehre” course, the subject of this paper. As we will note
in the section about precedents, there are several recent papers about using the connection between architecture and music in architectural pedagogy and research, see for example (Ham, 2006) (Christensen and Schnabel, 2008). What sets this project apart is the introduction of this topic in an entry level scripting class for architecture students as well as the large size of this class: over 130 participants. The implications of both will be discussed.

2. Teaching Scripting to Architecture Students
The class ‘Digital Methods of Design’ is taught in the third semester of the bachelor curriculum at the faculty of architecture of TU Graz. It is a mandatory class that provides the third component of a three-semester training in the fundamentals of representation, digital representation and digital design respectively. Though they have a theory component, a main goal of these foundational courses is to equip the students with the necessary skills to master the broad repertoire of digital media used in architecture.

While the classes in first and second semester focus on computer aided design in the more traditional sense, that is on drawing and 3D modeling as well as rendering and graphic presentation, the third semester has a focus on what we see as the lingua franca of the entire digital repertoire: scripting. While we in no way aspire to turn our students into actual programmers, we feel strongly that some acquaintance with algorithmic thinking and with the nuts and bolts of a scripting language will give them a better understanding not only of the digital tools they use in design, but more broadly of the increasingly digital world we operate in.

We have gained a considerable amount of experience in this type of teaching, which we’ve engaged in for many years. To keep it interesting for us teachers, we tend to choose a different topic to engage with every year. We have worked with landscape data, urban data, or pointclouds derived from various objects as our virtual building material. In 2015 we tried out something a bit more challenging: musical data.

3. Architecture and Music
The quote “architecture is frozen music”, which has been attributed to various authors in the Romantic period of early 19th century Germany, was considered a joke by some at the time it was coined around 1800. Michailov even suggests it was the fact that it was so often ridiculed which led to its wide dissemination (Michailov, 1992). The philosopher Schopenhauer, also often credited with being its author, refers to it as the ‘jokeword’ that Goethe coined - a joke because for Schopenhauer architecture and music were at the absolute opposite ends of the artistic spectrum. As he explains “architecture is solely in space, without any relationship to time and music only in time without any relationship to space” (Schopenhauer, 2016, p. 510). He does however go on to contend that “les extremes se touchent” - that there is a kinship in their formal composition or symmetry.

Of course the idea that there are links between architecture and music goes back much further. Vitruvius demanded that architects be proficient in many fields,
including that they ‘understand music’ (Vitruvius, 1914). Earlier still Pythagoras is credited with discovering the correspondence of mathematical proportions and musical intervals from which he is said to have derived the idea that order or harmony of relation is the regulating principle of the universe (Smith 1870, p. 621-22). The idea of harmonic form in analogy to musical harmony has been a constant in the development of Western Architecture. It can be found in the writings of Vitruvius as well as in Alberti’s system of harmonic proportions or Palladio’s four books, which describe dimensions of rooms based on the Pythagorean proportions. (Naredi-Rainer, 1982)

More recently the dual interest in architecture and music was very much alive at the Bauhaus. While music was not part of the curriculum it was a constant at Bauhaus events and a number of Avant Garde composers of the time such as Strawinsky, Busoni, Hindemith or Weill visited the Bauhaus. The famous ‘Mechanical Ballet’ by Oscar Schlemmer and others explored the connections between music and abstract geometric form. The Bauhaus masters’ interest in abstraction may also explain why Bach, whose work is often described as almost mathematical, was a favored composer of theirs. Lyonel Feininger, active as a musician in Bauhaus events, composed many fugues in the style of Bach. It is also worth noting that Kandinsky was friends with Schönberg who was also well-acquainted with Gropius. Schönberg in the early twenties, thus in the early years of the Bauhaus, invented the twelve-tone technique. The theory is said to have influenced Johannes Itten’s theory on color. (Jewitt, 2000)

4. Schönberg and the Chromatic Scale

The protocols and abstractions that underlie today’s digital music tools and instruments can be traced to the abstractions musical pioneers ushered in in the early twentieth century. Among them, Schönberg stands out not only as the inventor of twelve-tone music, but through the fact that he was an active composer as well as teacher and a theoretician. We named the class after his standard text book on musical harmony, titled “Harmonielehre” (Schönberg, 1919).

While Schönberg’s book stays within the realm of tonality, he does prepare the ground for atonal music in the final sections of the work. After a thick volume that explains and explores in great detail various modulation types and their bearing on kinship between different tonal scales, on page 464 he speculates that rather than seeing notes as always part of a group of typically 7 notes that make up a specific scale such as A Major, E minor etc., they could also be seen as part of a 12 note scale that encompasses all possible tonalities. In other words: he proposes the ultimate abstraction, an open field where every note is just a number (Figure 4). Thus with “Harmonielehre”, Schönberg not only explained in detail the great art of classical musical composition, he also paved the way for subsequent abstractions, including digital music.

Maybe the most well-known cross-over between architecture and music of the twentieth century came in the work of Greek engineer and composer Yannis Xenakis, while he was working with Le Corbusier. Both the Philips Pavilion at the Brussels World expo and the La Tourette monastery bear the mark of Xenakis’
unique musical-geometric compositions, which in turn also operate on the basis of this abstract open field (Xenakis, 2008). Rather than using traditional music notation, many of Xenakis’ scores use graphic abstractions and number-systems. The Philips Pavilion with its hyperbolic paraboloids was in fact based on Xenakis’ composition Metastaseis B (Figure 1) (Parthenios et. al., 2016).

5. Precedents

Xenakis’ works can be seen as examples of musical compositions translated directly into form (Figure 1). Thus, with Xenakis, the idea that one can “freeze” music to create an architectural form is not at all a joke, but a serious artistic method. Of course with Xenakis the case is special, because he is composer and architect at the same time and there is no debating with him whether his translation from these most distant artistic realms makes sense or is correct.

The more typical case is the translation of an existing composition by a well-known composer into a geometric form. Bauhaus student Heinrich Neugeboren (later known as the composer Henri Nouveau), probably influenced by the mentioned enthusiasm for Bach at the Bauhaus, created a sculpture based on a Bach fugue (Figure 2). Neugeboren’s work is often cited in literature about the topic. Architect and artist Jan Henrik Hansen follows in Neugeboren’s footsteps, but using digital means. His musical sculptures are based on music of different origins (Figure 3). Hansen started this work around 1999 (Hansen, 2006). He uses software he custom-developed for this purpose. He also came and gave a talk about his work at our university during the semester in which the class described in this paper took place. His sculptures were an important inspiration for the students (Hansen, 2018). Neugeboren’s sculpture is also referenced by Christensen, who has given a detailed account of how he has translated MIDI files of Bach’s Well-Tempered Piano into spatial structures (Christensen and Schnabel, 2008).
Figure 2. Heinrich Neugeboren (later known as the composer Henri Nouveau) created a sculpture based on a Bach fugue.

Figure 3. Musical Sculptures by Jan Henrik Hansen.

There is a growing body of research in the digital design field that specifically addresses and explores the relationship between architecture and music. Such research usually falls into one of the following categories:

1. Development of processes/software systems that enable a transfer of musical scores or audio signals into geometric (architectural) form.
2. Development of processes/software systems that analyze the harmonic properties of built form or turn geometry into sound/music.
3. Reports on educational projects that engage in the links between architecture and music.
4. Speculative projects that try to find synergies between music and architecture as a way to explore design.

In the first category, we’ve already mentioned the works of Hansen and Christensen. In the third category see for example the work of Ham (Ham, 2006). For the fourth type, see for example the work of Parthenios (Parthenios et al., 2016). Our work falls into the first as well as the third category. The structure of the setup is similar to the one described by Christensen. But rather than following a consistent procedure for a whole series of musical compositions and thus making it possible to compare them as geometric form, our approach was more open, more in the spirit of Hansen. We only provided a framework for students to work in. It had to be simple enough for even beginner programmers to use, but at the same time open enough for them to see it as a design challenge rather than a programming chore.
6. Technical Setup: MIDI and MEL

As mentioned, the framework for this enquiry was an introductory scripting class, a required subject for 3rd semester Bachelor students in architecture at our university. As a consequence neither prior scripting knowledge nor any particular affinity to music could be expected from students enrolled in the class. Thus, we had to prepare the subject matter and tasks in such a way that they could not only be mastered by novice programmers, but potentially also by tone-deaf novice programmers. And of course it was important not to lose sight of the main goal of the class, which is to equip students with a basic understanding of scripting and algorithmic methods in architecture.

As the basis for the scripting setup, MIDI-encodings of musical compositions were used. MIDI (short for Musical Instrument Digital Interface) is a technical standard that describes a communications protocol, digital interface, and electrical connectors that connect a wide variety of electronic musical instruments, computers, and related audio devices (Wikipedia, 2018). MIDI was standardized in 1983 and is a typical example of a digital format that is technically outdated but still widely used. For the sake of the class, its relative simplicity was a bonus. MIDI messages consist of a number of parameters such as beginning time, end time, pitch, velocity and others. Since these are all encoded as numbers, they can quite easily be mapped onto geometric properties, such as form, scale, position or orientation. (Figure 4) A further advantage of the MIDI format is that many MIDI transcriptions of classical and popular music pieces are freely available on the Internet. We made a set of 20 pieces available to choose from (ranging from Beethoven’s Cavatina to the Pink Panther theme), but students could also work with any other composition of their choice, as long as they had a MIDI file for it.

![MIDI notes are simply numbers - an open field.](image)

With a converter, MIDI files were turned into CSV documents that could in turn be imported into the Software Maya. Autodesk Maya is a 3D computer graphics application commonly used in animated film, visual effects and 3D interaction design. Due to its node-based structure and scripting interface it has been used for many other purposes as well, including in digital architecture. We used it for many years in our scripting class, because of the convenience and relative simplicity of MEL, the Maya Embedded Language.
In preparation of the class we created a custom MEL library of functions, which included functions to import the MIDI files. For the students the two translations from MIDI to CSV and from CSV into Maya happened in direct sequence. Unless they wanted to manipulate the MIDI files (e.g. shortening them or reducing the number of tracks in them) they didn’t have to open the CSV files at all.

7. Keeping things simple

We mentioned that MIDI is a fairly simple standard and that MEL provides a convenient scripting interface. To be fair, this is speaking in relative terms. For a novice programmer the setup is still very complex. So to make things understandable and easy to use was an important goal. First of all we let them use MIDI-viewers as ways to see and listen to the MIDI files they wanted to work with. We also encouraged them to study the CSV versions of their MIDI files even though that wasn’t strictly necessary. We wanted them to have a solid understanding of the nature of the data they were working with. Finally we found a trick that proved very helpful: when importing the CSV file into Maya the data in it was automatically stored as nodes without geometry. Using the so-called Outliner, a Maya tool that allows users to view the content of a scene in list format, students could check out the imported data before they even started creating any scripted geometry based on it (Figure 5). Since the names of the nodes also contained the most important parameters, such as beginning time, end time, pitch and velocity, viewing the data in the outliner was similar to viewing the CSV data in Excel.

Another convenience we provided was a function we called ‘explain_midi’. It listed the most important parameters of a given midi files and calculated useful
values based on them, such as overall length, start and end time, the number of measures, the length of a measure, the lowest and the highest note in a track, the loudest and softest notes in a track and the corresponding difference between these values.

8. It’s frozen music, but is it architecture?

Figure 6. Typical projects mapped musical rhythms or patterns along spirals or towers.

Figure 7. Bach’s crab canon interpreted as an airy, jellyfish-like mobius strip.
A constant in our pedagogy is that we value creative explorations over proper programming style. Students work in groups of two, which in our experience not only improves the result, but also the learning, as they tend to discuss ideas and strategies. In the final stage of the class, which was held as a five day workshop, held in the course of two weeks, we focused on creating renderings of their spatial compositions. Based on our preparations for the students, a literal rendition of a score, that is one that more or less replicates the notes as they appear on a music sheet, was straightforward to achieve, but not necessarily very interesting. (Figure 5) Typical projects instead tried mapping musical rhythms or patterns along spirals or stacked as towers, using the rhythms, melodies and the different instruments in the chosen score as overlaid patterns (Figure 6). Some were remarkably sophisticated, for example the group that explored the famous crab canon by Bach, which they interpreted as a Mobius-strip and rendered as an airy jellyfish-like structure (Figure 7). Others created what could be read as interpretations of or commentaries about the music, such as the group that turned the score of a Bruckner symphony into what looked like a contorted megastructure (Figure 8). While some groups tried to translate as much of the data as possible and to find meaningful spatial or visual cues for all MIDI parameters, it wasn’t necessarily clear that the groups that did so had the more successful results. Also, while structuring the spatial data such that simultaneity of different tracks or the structure of individual measures would remain visible in the resulting spatial composition was a good design choice and gave the results a certain legibility, there were many successful designs that didn’t adhere to such constraints. Interestingly even the ones that made it all but impossible to recognize the piece they had worked on still retained a certain musicality in their expression.

What the project made clear is that there isn’t a correct way to turn musical data into spatial structures. The difference between what Schopenhauer defined as the space-based art of architecture and the time-based art of music is so vast that the quest for the one “correct” translation in this case seems pointless. There are countless options of going about it. Any translation is also an interpretation.
9. Conclusion

This paper has reported on a teaching experiment that allowed students to explore spatial potentials of musical data as a way to learn about scripting. While students took the class as a mandatory subject and thus were not necessarily interested in music or scripting, many of them enjoyed the speculative task and were surprised to discover that scripting afforded them a personal form of expression.

The conclusion we draw from the experiment is that as a way to learn about scripting and algorithmic design the class worked as well as other scripting classes we have taught in the past. But beyond the practical learning, students reported that they enjoyed the creative nature of the topic. It’s for good reason that exploring the similarities between architecture and music has a long tradition in architecture. Students were challenged to re-think and reevaluate notions they may have had about music as well as about space and scripting. As a pedagogical and philosophical experiment, it is worthy of repetition.

References


