ANISOTROPIA: MORPHOLOGICAL SOUND ANALYSIS

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ARCHITECTURE AND MUSIC

Music and architecture are two very different form of art, one if very ephemeral while the other is very concrete, yet still there are many relations between them, and many design concept can become applicable to both. Spaces as well as music can manage to evoke very similar emotions, and we use words like 'composition', 'structure', 'rhythm' or 'colour' for both of the disciplines.

Although traditionally treated quite separately, especially during Romanticism the relations between music and architecture started to be more closely investigated, by philosophers such as the Schlegel brothers and Brentano. And it was Wilhelm Joseph Schelling who described architecture as "frozen music", a metaphor which has been famously quoted by Johann Wolfgang von Goethe.[02]

PROGRAM MUSIC

Direct translations of one discipline to the other started to appear in classical music within program music, in which, opposed to absolute music, composers use extra-musical narratives that are described through the compositions. Already appearing in the Renaissance and Classical period, but with its peak during Romanticism, composers often described spaces and landscapes, and sometimes specifically buildings and architectural spaces. An example for this is the piece Vltava by Bedrich Smetana, also known as The Moldau, in which he tone paints the river of his homeland[03], and the cycle Pictures of an Exhibition by Modest Mussorgsky. In it Mussorgsky musically describes the visit through an exhibition of paintings by Viktor Hartmann, including the movement titled The Bogatyr Gates, which depicts Hartmann's design sketch for new city gates in Kiev.[04]

The romantic musical translations from space to sound tended to happen on an emotional level, where the feelings of a spatial situation were translated into correlating music, or where specific sounds of a situation are mimicked by the instruments.

NOTATION

Both music and architecture are forms of art which require additional mediums for their transmission and proliferation, other than just the piece itself or a depiction of it: Both are transmitted via a notation, via drawings which are made to describe the sounds or a building to other people, who are then able to create or re-create the intended piece. In musical notation this happens via a symbolisation along time and frequency directions, in architecture via a combination of both diagrammatic depiction and symbolisation.

SCRIPT

Already the notation of script takes a sound, a word, and turns it into a physical product, into a formation of ink on paper, or into carved grooves within a base material. The first step was the development of a symbol: The material formations or abrasions symbolise meanings which are orally represented by sounds, and their notation becomes a physical manifestation of those sounds in a quasi two-dimensional object.

TIME AND SPACE

Importantly, in a second step the symbols have been placed in an order and they are read in a certain direction. With all writings we start to read at a start point, and following the symbols we move towards the end, usually in a linear manner, or quite often in a broken linear manner as in a text which is written across several rows and pages.

Like this, time has been translated into space. The spoken sentence unfolds for a specific duration in time, the written symbolisation of it unfolds on the paper in space, the time dimension has become a spatial dimension.

MUSICAL NOTATION

Similarly in musical notation, the time dimension gets transformed into a linear or broken linear spatial dimension. One of the most important aspects of music which gets symbolised in the notation is the pitch, the base frequencies of the sounds which are to be created. In most musical notations, the notation of the pitch happens in a second dimension: Where the time dimension is read in a horizontal manner, the pitch is read vertically. This applies to the notation using modern musical symbols, but it also applies to early western or Asian forms of musical notation.

Also the pitch of a sound is a property which is time-based, it is the duration at which the waveform of a sound is repeated in time. Therefore also the notation of the pitch in the vertical direction is a transformation of time to space.

In gramophone records and CDs, both time and frequency of music are transformed into physical objects, in both cases the time dimension gets transformed into a curved linear space dimension.

XENAKIS

Using this relation, the architect and composer Yannis Xenakis managed to relate both disciplines on a structural level, by applying the same concepts to both his musical and architectural compositions, in his case mostly mathematical concepts. His applications happened by treating time and space similar between the two forms of art, which also reflects in the notations which he uses for both his music and his architecture.

METASTASIS

This becomes apparent when comparing his composition Metastasis with, for example, the Philips Pavilion, which he designed whilst working at the office of Le Corbusier. Both are making us of hyperbolic paraboloids, the pavilion in its concrete shell geometry and the composition in the glissandi of the strings.

> "In the Philips Pavilion I realised the basic idea of Metastasis: as in the music, here too I was interested in the question of whether it is possible to get from one point to another without breaking the continuity. In Metastasis this problem led to glissandos, while in the pavilion it resulted in the hyperbolic parabola shapes." [07]

The relationship between the two becomes especially clear when comparing the notation of both Metastasis and the Philips Pavilion: In the pavilion, two straight beams or columns, which are not parallel to each other, are connected by a net of evenly spaced straight steel cables, which eventually form the hyperbolic paraboloid built in concrete. The two states, the beams or columns at either end, are at each point connected by a straight line, the steel cables.

The same principle is visible in Metastasis: The glissandi start as an even cluster, the first state, and each instrument then moves along a straight glissando towards its next stage, resulting in a lyrical hyperboloid. The notation of Metastasis shows the same crossing contour lines which as visible in the structure of the Philips Pavilion, the spatial directions of the building have become the temporal directions of the composition.

> "Time and space are modes by which we think and not conditions in which we live."[08]

A FROZEN SOUND

Using the principle of transforming sound into form by translating its intangible temporal attributes into physical directions in space, a sound can be analysed, digitally dissected and transformed into an object. Using acoustic analysis softwares, various time-based attributes of a sound can be digitally analysed and then be represented spatially. For "A Frozen Sound", different attributes of a sound have been extracted such as its behaviour over time, its melodic range and its peak frequencies. They have been turned into a multi-dimensional spectrogram, a three-dimensional notation, an object which is as much analysis as it is representation and a physical design based on the sound.

Figure 1. A frozen sound

ATMOSPHÈRES

In a similar way that A Frozen Sound is the transformation of a sound into space, Atmosphères is the translation of a composition for orchestra by György Ligeti. It manifests as a spatial surface within the ceramic cladding panels, forming the new façade for Hotel G, a boutique hotel in Beijing.

The existing building requires a refurbishment of the deteriorated upper parts of the exterior, and Orproject's proposal envisages the installation of a new cladding in front of the existing walls. The complex morphologies of the ceramic panels are to be manufactured using a simple, semi-manual form of multi-point forming: The heights of a field of pistons are positioned according to 3d data from the digital model. Then the clay for each panel is draped over the field to form the surface. Adjustments by hand are necessary before the shape is left to dry and fired.

The geometries of the façade have been derived from a digital analysis of Ligeti's composition. Ligeti's Atmosphères uses large clusters and sound textures which slowly merge from one into the next, resulting in an atmospheric field of sound. In its translation into space, the time dimension has been placed vertically, moving

towards the sky. Therefore the slow musical transformations are resulting in a vertical orientation of the façade morphologies, which is useful in Beijing's climate in order to avoid shallow inclinations of the facade.

The complex clusters are turning into a continuously altering surface geometry, and Ligeti's use of micropolyphony is resulting in a micro shifting of the façade formations.

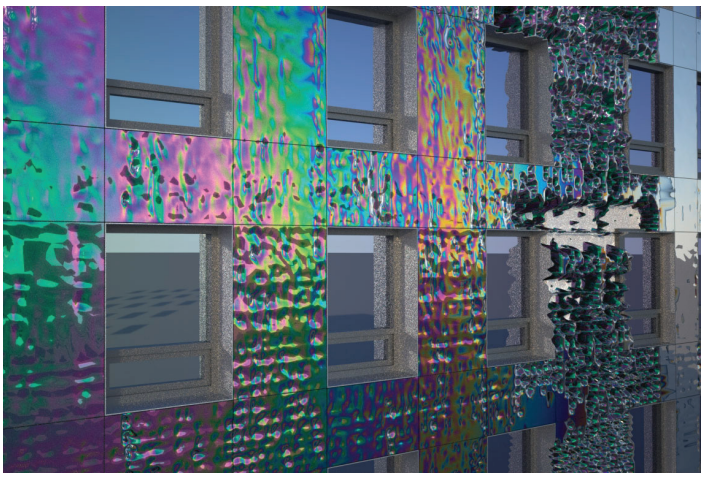

Figure 2.

AUDIO ANALYSIS

Audible sounds are vibrations at certain frequencies of a medium around us. Sound waves always propagate through a physical compressible medium, such as the air. The air oscillates longitudinally back and forth, and causes our tympanic membrane to vibrate in the same way. However rather than noticing differences in the air pressure around us, we recognise the frequencies at which the vibrations occur. This already constitutes a natural level of abstraction between the information which is recognised by our ear, the differences in air pressure, and the information which is perceived by our brain, the corresponding frequencies.

The same is the case for digitally recorded sound waves, the audio data, which can be used for digital sound analysis: They are air pressure values at repetitive moments in time. The volume of the sound waves can be extracted from those data easily, it is defined by the maximum and minimum pressure value within a certain duration.

In order to extract the frequency values from those data, a mathematical method is used called the Fourier Transform. Using the Fourier Transform all the simultaneously occurring frequencies of a sound can be calculated, and from those it is then possible to define the base frequency of a tone together with its overtone spectrum, and based on that any other information relating to the frequency aspects of the sound. The frequencies and volumes of a sound usually change over time, which is reflected in the analysis.

DATA REASSIGNMENT

However, precisely defining a frequency requires constant data for a certain length of time, which do not exist for a sound which is changing quickly, and as a consequence the outcomes of the Fourier Transform will result in blurred data.

In order to sharpen those data and to extract precise frequency information, a reassignment of the values to their closest peak can be applied. This reassignment requires a time window length to be assigned, which can be chosen as longer or shorter, and which will enhance the focus on either the harmonics or the impulses of the sound. In a complex harmonic situation, such as in rapidly changing spectrums or in human speech, we can choose at which intensity to focus on either the harmonics or the impulses, but we are not able to precisely define both at the same time.[12]

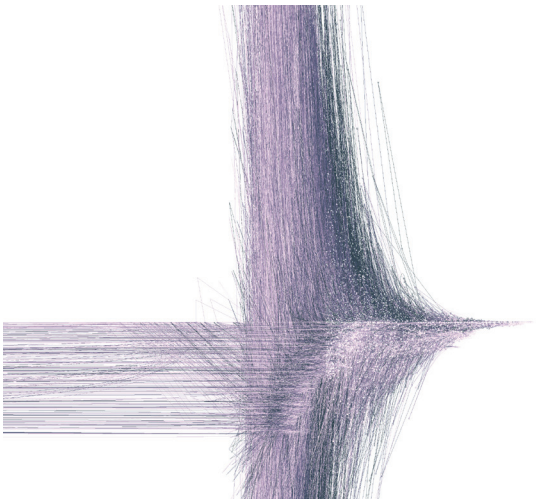

Figure 3. Reassigned sound data

CHUAN

An interesting result of the data reassignment, especially when transformed into 3-dimensional morphologies, are the repetitive data accumulations in parallel strata, which are caused by the analysis of the sound according to different time windows. The strata generation has a tendency to be linear, however shifts are occurring at intervals which realign the data according to the harmonic transformations of the sound sample.

For the piece Chuan, the human voice has been analysed with a relatively short time frame, which focuses the analysis onto the guttural sounds rather than on the longer lasting harmonics. The geometry results in a mostly vertical lattice, with complex joints at the points where a shift occurs from one alignment towards the next.

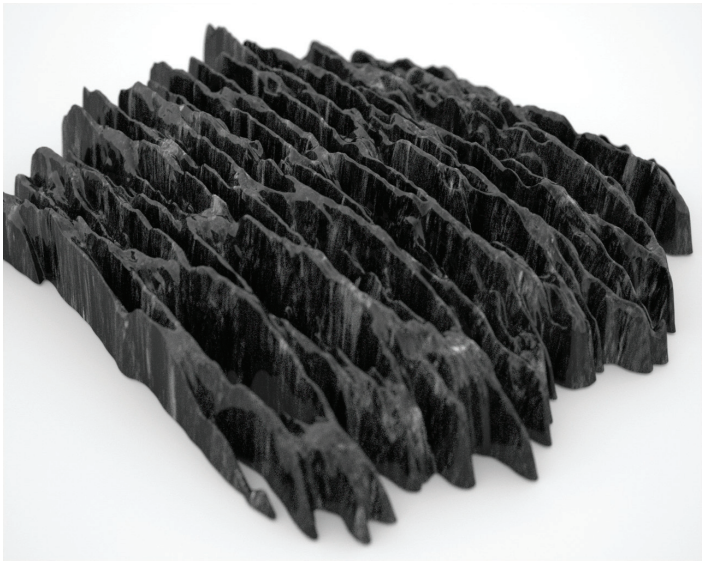

Figure 4. Chuan

ASUVATI

Evaluated architecturally, the generation of shape based on the analysis of reassigned frequency values allows us to generate both a horizontal as well as a vertical repetitive system, together with the fluent transition between the two. The harmony-focused analysis of a sound, as a result of its repetitive overtone frequencies, results in repetitive horizontal layers, whereas the impulse analysis results in shifted, repetitive vertical information. The combination of the two lends itself to the use as a structural building system, as it can provide both horizontal floor plates as well as vertical columns or walls between them, and structural connections which transmit the forces between those two.

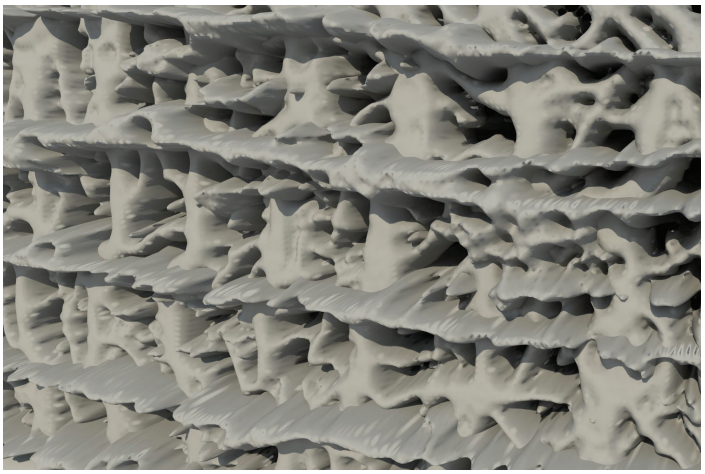

Figure 5. Asuvati

This principle has been applied in the design of Asuvati, a mixed-use multi-storey complex with two towers connected by a podium. The horizontal floor plates slowly gain in inclination towards the facade, turn into the spaces for vertical circulation, and then form the vertical structure and the facade of the building. The analysis of varying time frame sizes has been used to create a continuous monolithic object which fulfils different structural functions throughout its volume, the originating sound has become a diagram of the building's distribution and density in space.

MUSIC AND ARCHITECTURE

As different as music and architecture are, the two forms of art also have very close relations, and their inherent logics become visible when one is transformed into the other. However the importance lies in finding and using the relevance of their relation, so that their morphologies can be turned into functional architectural proposals.

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