Sound Colour Space – A Virtual Museum*

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ABSTRACT

By investigating the conceptual field of sound, tone, pitch, and timbre in its relation to visual phenomena and geometrical concepts, the project Sound Colour Space – A Virtual Museumcontributes to an interdisciplinary field of research and explores its adequate modes of representation and communication. Many scientists and philosophers from antiquity to modern times have studied the relationships between sound, light and geometry. Many of their visualisations of acoustical, optical and perceptual topics speak to the eye and can be studied comparatively. These pictures are interesting because of their diagrammatic structure, in the way they combine text, images and spatial structures on a flat surface and in the way they address topological, philosophical and psychological questions. They often have an aesthetic value of their own. In addition to the development of an exemplary online publication, interactive audiovisual examples were created, which also were used for artistic projects.

1.   INTRODUCTION

The collection and study of these materials and the attempts to present them as a sequential text lead to the question of adequate forms of representation. Since a given picture or graphic can appear in various contexts and with different implications, a distinct network architecture permits forms of content representation free of redundancies in a way that is difficult to achieve in textual form. Accordingly, a collection of scientific illustrations and diagrams (currently about 600 image files) together with related materials and findings is presented within an open, dynamical online publication. The metaphor «museum» is thus rendered as a place where people and objects meet and interact in various dynamic modes. Visitors gain access to the collection of pictures and they can compare and regroup the pictures, read explanations and interact with audio-visual applications, or just follow guided tours. Scientists use the museum as a research tool and add to the contents of the underlying database. The application is based on the Media Archive of the Arts developed at Zurich University of the Arts and contributes to the further development of this online platform as a research tool. [1]

2.   THE VIRTUAL MUSEUM

2.1   The final implementation

In the following, we say *museum* or *virtual museum* in order to refer to the final implementation of the virtual museum "Sound Colour Space". [3] The term is used for both, the software and the way it presents itself to the users (visitors). With *media archive* we refer to the Media Archive of the Arts of the Zurich University of the Arts, which is based on the software Madek. There are three types of semantic units or exhibits in the museum: *items*, *item groups* and *experiments*. An *item* consists of a picture (image file) and meta-information. An *item group* consists of a set of items and meta-information. An *experiment* is an audio-visual application with meta-information.

The items are stored as *media* in the media archive, where they are given title, author, year, bibliographic information and keywords, and grouped into *sets*. This makes sure that these data are available in the longer term.

The museum uses the application programming interface (API) of the media archive to synchronize the items and item groups with their counterparts in the media archive.

Since the annotations of the items and item groups contain formatted text, formulas and cross-references, they are stored in the database of the museum. They have been prepared in rich text tables.

The *Archive* of the museum accesses the items in a way similar to a library system with various search, filter and representational functions.

The *Timeline* visualizes the diagrams and their meta-information on a time axis.

The menu *Sets* leads to the item groups – defined in the media archive as sets – and their meta-information.

The menu *Keywords* opens a list of all the keywords assigned to items. Selecting a keyword displays the related diagrams and an optional definition of the keyword.

Besides the presentation of static contents the *Virtual Lab* offers an array of interactive audio-visual exhibits, which were created for this project. They can be run directly in the browser (Firefox, Safari and Chrome).

The menu *Exhibitions* contains paradigmatic exhibitions with free content as well as exhibitions based on the collection of the museum.

Figure 1. Archive: list view

Figure 2. Archive: tiling ("Petersburg hanging")

2.2 DATA MODELLING AND PROTOTYPE

In collaboration with Christoph Reuter a first data model was created in February 2015.
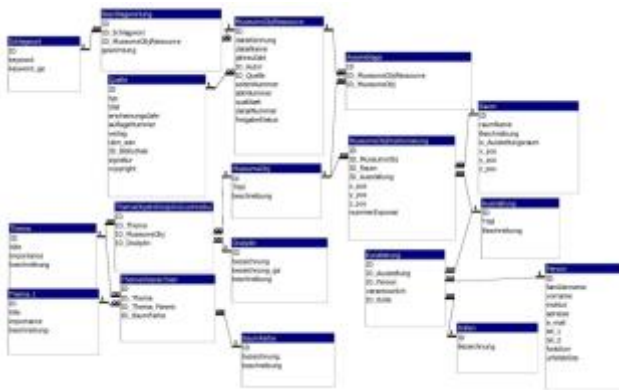

Figure 3. ER-model (25.2.2015)

The many-to-many relationship 'Assemblage' between the central entities 'MuseumsObjRessource' and 'MuseumsObj' links the resources (media, files, typically diagrams) to semantic units or exhibits. The 'MuseumsObj's are similar to the sets of the media archive, however there is no further structure that would bring them into a network or a hierarchy. Keywords are given to the resources, but no additional semantic context. The lower left part of the model describes a kind of ontology, where the network of

topics related to the 'MuseumsObj's could be explored by means of "differently coloured trees".

In summer 2015, the data model was partially implemented into a prototype by Daniel Muzzulini. The prototype used a mySql-database and was programmed with php, JavaScript and jQuery/Ajax. This early draft of the museum holds 150 diagrams (partially with realistic meta-data). There are no interactive exhibits in the prototype.

Figure 4. ER-model (prototype)

It turned out that many items (resources) form semantic units in a natural way, so that no further documents are needed to turn them into exhibits.

A semantic context as well as keywords can be assigned to both, items and item groups, in form of metadata.

In the archive view of the items, the collection of diagrams can be filtered through time spans and keywords. By selecting items from a list they are shown together with their meta-information in a simple lightbox, where they can be moved up and down or removed.

In the archive view of the item groups, an item group can be selected from a list, so that all its diagrams and related meta-information are shown.

An *exhibition* is an ordered collection of exhibits. There are three types of exhibits: single *items*, *item groups* and *walls* holding one or several item groups in a matrix arrangement.
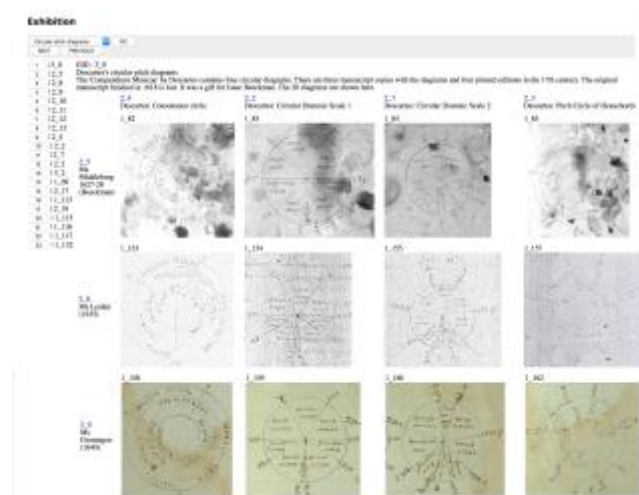

Figure 5. Example of a matrix wall as part of an exhibitions.

3. TOPICS, INFORMATION TECHNOLOGIES AND RESEARCH PRACTICE

3.1 Conception of the Virtual Museum

For the conception and functionality of the application the metaphor and terminology of a museum was helpful. The application primarily addresses researchers and scientists in the areas of music theory and diagrammatics. Although there is a close connection to the media archive of the Zurich University of the Arts, the access through a separate interface with special features for searching, sorting and viewing is essential for experts and visitors. For the development of the frontend interface several layouts, mood boards and sketches of the virtual museum were created and were helpful to build a responsive design.

Figure 4. Mood board and wireframe

Beside the archive and the access to its contents through a database, exhibitions should be a part of the museum. According to Sybille Krämer's theory of "the cultural technique of flattening" (Krämer 2016) [12] diagrams in web-technologies can be used to generate knowledge through flattening multidimensional information to a two-dimensional level. Following this idea, a collection of exhibits, the exhibition itself, can be seen as a network of information, which is presented by an "operative image" (Krämer 2009) [11], a diagram itself. This concept naturally leads to navigation tools for exhibitions. As Gerhard Dirmoser emphasizes, a digital realization of an exhibition is like a tour of a museum. His theories and layouts were helpful to design new exhibitions.

Figure 5. Layout for an exhibition by Gerhard Dirmoser and for "Chromatic Scales"

3.2 Virtual Lab

It was necessary to evaluate the possibilities of web-technologies for the interactive audiovisual applications. The abilities of HTML5 and the diversity of JavaScript libraries led to the idea of a virtual lab, as a place where different experiments with interactive applications can take place in the web. In an early prototype a first example was developed, which can be changed and edited directly in the Browser. The application consists of two parts: a layer in which the interactive diagram is generated and a separate layer where the settings and the synthesizer can be placed. A Web Audio library was created, which is used by all the examples and can be adjusted to the needs of the examples.

For these experiments different strategies were used: Existing pitch diagrams were made audible through Web Audio, so that they can be used in demonstrations and education. Some examples create new diagrams, which help to compare musical scales defined by different authors. Other examples create a graphical template of the scales under consideration, which can be compared with the historic diagrams. These interactive exhibits are programmed with p5js, a JavaScript library, a project of processing.org, offering the same functionality as Processing. Processing is used by many media artists. Some adjustments are necessary to convert processing programs for the web. [2]

4. CASE STUDIES

4.1 Syntonic chromatic scales

With *syntonic tone system* we refer to the infinite set of pitch classes defined by fifth of the ratio 3:2 and major thirds of the ratio 5:4. The task of defining a chromatic scale in the syntonic tone systems has many different solutions. Furthermore, since e.g. c-sharp and d-flat are different pitches in the syntonic system, it is even not a priori clear that a chromatic scale should consist of twelve pitch classes. Suggestions by Lodovico Fogliano (1529) [8] and Francisco Salinas (1577) [15] had 14, 15 or even 24 different pitches per octave. Various chromatic scales with twelve notes were given by Johannes Kepler (1619) [10], Marin Mersenne (1636) [13], Isaac Newton (1665) [14], William Holder (1694) [9] and Leonhard Euler (1739) [7]. The problem with these scales is that most of the diatonic scales in different keys are distorted forms of the original C-major scale: they contain fewer perfect major triads (4:5:6) and perfect minor triads (10:12:15). Positively said, the different keys have a specific interval structure ('Tonartencharakteristik'. For example, Holder's chromatic scale contains seven structurally different major triads.) The virtual museum hosts interactive audio-visual exhibits (figure 6 and 7), which allow the comparison of the various chromatic scales, as well as an exhibition on chromatic scales [4].
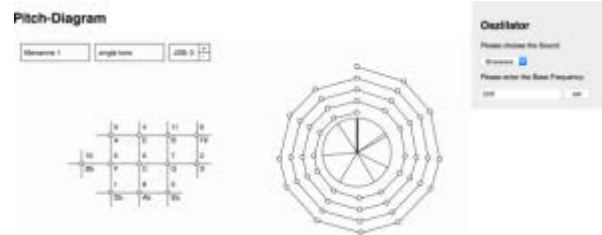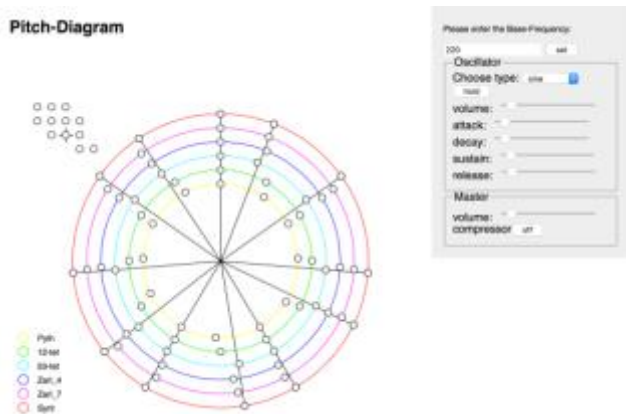

Figure 6. Interactive Example "Chromatic Spiral"

Pitch-Diagram

Figure 7. Interactive Example "Chromatic Circle"

4.2 Comparing diatonic scales

René Descartes's "Compendium musicae" contains a circular pitch diagram of the syntonic diatonic scale with an ambiguous second degree. [5][6] The different versions of the diagram from the manuscript copies and early prints can be explored with this interactive application. The user can place a transparent reference diagram on the diagram under consideration. The reference diagram is calculated with logarithms and can be shifted, rotated and adjusted in size. The deviations of the angles in the drawings from their accurate representation are made audible with a sweeping sound controlled by the mouse pointer.
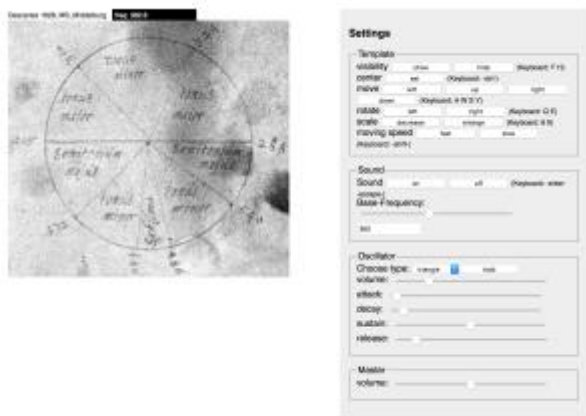

Figure 7. Interactive Example "Descartes – Diatonic Scale 1"

5. Play Descartes

In order to explore its potential for art projects an interactive audio-visual exhibit developed for the virtual museum was used in a performance. Hereby, scientific knowledge and its digital representation was an inspiration for a cross media project. The pitch diagrams were connected over a network to sound synthesis programs through Open Sound Control (OSC). In the performance "Play Descartes" the diagram was used as an interface which can be controlled in the browser of mobile devices. By using their smartphones the audience produced a composition in the collective.

6. CONCLUSION

The database and the collection of diagrams is a useful tool for researchers in the area of music theory and diagrammatics. The creation of interactive examples and exhibitions leads to a deeper understanding of complex topics. The application works well in combination with the Media Archive of the Arts (Zurich). It is paradigmatic for further developments of this kind. [16]

7. ACKNOWLEDGMENTS

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