SOUND TO SCALE TO SOUND, A SETUP FOR MICROTONAL EXPLORATION AND COMPOSITION

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ABSTRACT

This paper elaborates on a setup for microtonal exploration, experimentation and composition. Where the initial design of the software Tarsos aimed for the scale analysis of ethnic music recordings, it turned out to deliver a flexible platform for pitch exploration of any kind of music. Scales from ethnic music, but also theoretically designed scales and scales from musical practice, can be analyzed in great detail and can be adapted by a flexible interface with auditory feedback. The output, the scales, are written into the standardized Scala format, and can be used in a MIDI-to-WAV converter that renders a MIDI file into audio tuned in a particular scale. This setup creates an environment for tone scale exploration that can be used for microtonal composition.

1. INTRODUCTION

Pitch and tone scale organization is one of the many interesting musical parameters, but it is foremost the oldest one that has been studied. In ancient Greece, several scientist/philosophers searched for the intimacies of sound and its sympathic vibrations. Using a monochord, Pythagoras revealed the intervallic ratios for his tuning system that was used for ages. It was the beginning of an adventure between mathematical and physical theories versus sounding realities and musicality, where people enigmatically spoke about commas, wolf tones, theory of affects and temperaments. In Western music, music theory developed gradually towards an equal temperament, with some exceptions by experimental composers. In non-Western classical music however, many alternative tuning systems that use specific intervals such as quartertones have been described. In oral music, one encounters even more different scales, that were developed in a master-student relationship, tangled in a functional and societal context and less depending on theoretical framework.

Nowadays music has become a digital object. Individual people, large museums and archives, all of them like to provide digital copies of their analogue recordings to create an easy-to-browse collection. These digital objects also have a completely different research potential. Music and sound can be analyzed as a physical or symbolical string of information; it gave birth to the Music Information Retrieval community, that aimed at automated computational analysis of any musical parameter. In this context, we have developed Tarsos[1]. It was especially designed for the analysis of pitch in African music. The specific characteristics of tone scales in this wide range of music, urged us to develop a very flexible system for pitch analysis, pitch representation, pitch (and scale) interpretation and fitting forms of output. It led to the java platform Tarsos where both automated and manual analysis are implemented in an interface where users can alter any found pitch suggestion, thus listen and verify in order to retrieve the used tone scale. This prior goal soon extended towards small use cases in listening to the unique qualities of retrieved scales. It was a pilot for a more systematic approach to alter Tarsos in such way that it becomes a tool for microtonal experiment as well. Nowadays several options are built in the software that makes microtonal composition much more easy and accessible. Any scale, retrieved from analysis, based on theory, or created from experiment, coupled with a score can be rendered into a WAV-file using a MIDI synthesizer.

This paper is structured as follows: an introduction sketching the background for this research. Chapter two will provide a view on the methodology. Chapter three documents several case studies. The final chapter states aspects on future work.

2. METHODOLOGY

Figure 1 summarizes the setup for this microtonal experiment in a circular triad. The software Tarsos explores and extracts scales, the software Scala gathers all the files and serves as a basis for the auditory feedback, note by note or converting MIDI to WAV-files.

2.1. TARSOS, inner workings

Most software tools for pitch analysis focus on Western music, and thus focus on a pitch organization of 12 pitch classes per octave, in an equal temperament, that is 100 cents per interval. However, to fill the need for pitch analysis of ethnic music, another approach was needed that

[1] Tarsos, together with a manual, the source code and other documentation, can be found at http://tarsos.0110.be.

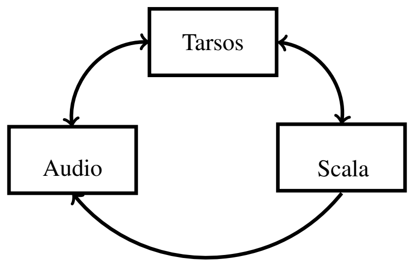

Figure 1. Circular triad between input and output; Tarsos analyses audio, Scala organizes the output of the analyses, which can be uploaded again in Tarsos so any scale can be rebuilt and sonified.

has a much more fine grained range of pitch possibilities. Tarsos has been designed especially for handling microtonal series of pitches. Pitch annotations are extracted from an audio signal by counting how many times each fundamental frequency is repeated throughout that audio signal. Those annotations are processed in such way that they generate musicological meaningful representations, which is not straightforward for ethnic music that relies on completely different musical concept of pitch, pitch perception, scale and its possible meaning. The specific initial intention of Tarsos is to offer a flexible system for pitch annotation by its combination of graphical interface, filtering options, manual and automated annotation processes and direct auditory feedback. The use of a fine-grained histogram that allows up to 1200 values per octave, makes Tarsos convenient for studying pitch deviations in music, and for studying specific tone scales that differ from the equal temperament as appears in many non-Western music. Tarsos has both a graphical user interface, a command line interface and an application programmers interface (API).

For a detailed technical description about Tarsos, see [6]. Summarized: first the audio is analyzed in blocks of 10ms and for each block a fundamental frequency estimation is made by several available pitch trackers namely MAMI[3], YIN[2], MPM[4] and some Vamp plug-ins [1]. Thanks to a modular design, internal and external pitch detectors can be easily added. Secondly, the frequencies are converted to the cents scale with the C below C0 set to zero cents while maintaining a list with the number of times each frequency occurs.

That information is visualized in a number of ways. A first type of visualization is the piano roll representation. In this representation each annotated pitch is plotted over time. A second type of visualization is the pitch histogram, which shows the pitch distribution regardless of time. The pitch histogram is constructed by assigning each pitch annotation in time to a bin between 0 and 14400 cents, spanning 12 octaves. Reducing the annotations to one octave, obtained by adding each bin from the pitch histogram to a corresponding modulo 1200 bin, builds a quasi-continuous pitch class histogram of 1200 values, which is the third type of visualization. Peak detection on the pitch class histogram results in an interval table, that contains the tone scale and all of its intervals. All visualizations and the table interact directly: e.g. changes made to the peak locations propagate instantly throughout the interface.

2.2. SCALA gets the scales

Scala[2] is a software tool for experimentation with musical tunings, such as just intonation scales and non-Western scales. It supports scale creation, editing, comparison, analysis, storage... Exploration of tunings and scales fits Scala very well. The Scala program comes with a dataset of over 3900 theoretical scales ranging from historical harpsichord temperaments over ethnic scales to scales used in contemporary music. Scala files are text files that contain tone scale information. The .scl text file format is defined by the Scala program. Tarsos can parse and export Scala files. Tone scales built within Tarsos that are exported use the Scala standardized .scl format. When used as input for Tarsos, these .scl-files can e.g. be used to compare with histograms that were extracted from audio. Scala files can also be used to compare different tone scales within Tarsos or within the Scala program.

2.3. TARSOS towards sound

There are several options to get sound out of Tarsos. A first one uses the interactive histogram components. One can listen to any histogram in Tarsos by clicking it. A click sends a MIDI-message with a pitch bend to synthesize a sound with a pitch that corresponds to the clicked location within the histogram. A second option is the interval table. In the interval table, one can listen to every detected pitch class or every possible interval between two pitch classes. The interval table, as mentioned before, can be constructed from audio (via peak detection on a pitch class histogram) or from an imported Scala-file.

The third and last option, and perhaps the most practical one, is to use a MIDI keyboard. The MIDI Tuning Standard defines MIDI messages to specify the tuning of MIDI synthesizers. Tarsos can construct Bulk Tuning Dump-messages based scale information - again, either from a Scala-file or from an analzed audio file - to tune a synthesizer. Since most hard- and software synthesizers ignore these messages Tarsos contains the Gervill synthesizer, one of the few software synthesizers that do offer support for tuning messages[3]. This makes it possible to play live on a MIDI keyboard, or to process a MIDI file and render it in an arbitrary tone scale.

[2]Find the website of the Scala software program at `http://www.huygens-fokker.org/scala/`

[3]Another approach to enable users to play in tune with an arbitrary scale is to send pitch bend messages when a key is pressed. Pitch bend is a MIDI-message that tells how much a higher or lower a pitch needs to sound in comparison with a standardized pitch. Virtually all synthesizers support pitch bend but it is hard to imitate a tuned keyboard using only pitch bend messages. Pitch bends operate on MIDI channel level which makes it impossible to play polyphonic music in an arbitrary tone scale on one channel.

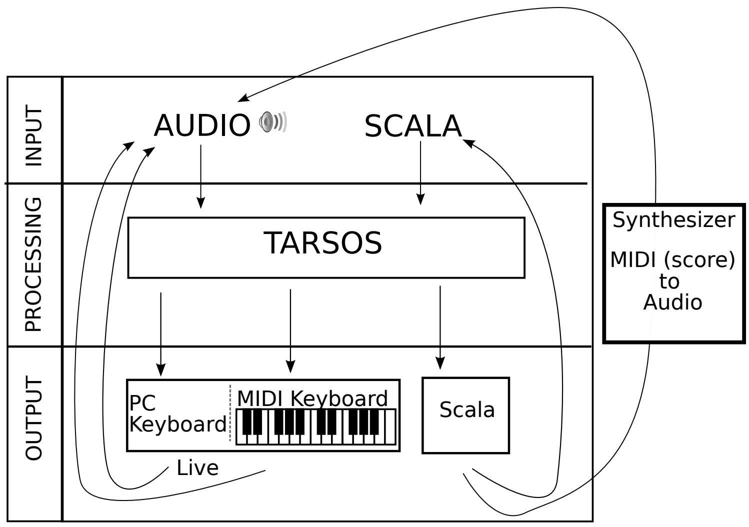

Figure 2. Detailed circular triad as a block diagram for microtonal exploration and composition

Figure 2 shows a conceptual visualization of different interactions and sonifications. As can be seen, it is e.g. possible to start with an audio file audio, export a scala file with a detected tone scale or play a MIDI keyboard.

3. CASE STUDIES

The aim of this research is microtonal composition based on exploration of musical pieces that contain microtonal pitch classes. Therefore some case studies have been chosen to raise a corner of the veil.

3.1. Ethnic scales

Ethnic music offers a unique environment of characteristical timbres, rhythms and textures that need adapted or completely new, innovative tools. The potential of computational research within the context of ethnic music has been stressed by the introduction of the term Computational Ethnomusicology[7]. Hopefully this new interdisciplinary (sub)field can give an impulse to the study and dissemination of a rich heritage of music that is now hidden in archives and aid or even stimulate new musicological field work [6]. As an example for computational pitch analysis, an interesting song is found in the archives of the Royal Museum for Central-Africa (RMCA, Belgium). This song, recorded in Burundi in 1954 by missionary Scohy-Stroobants, is performed by a singing soloist, Leonard Ndengabaganizi. The detected intervals, visualized in Figure 3, are respectively 168, 318, 168, 210, and 336 cents; a pentatonic division that comprises small and large intervals, rather than an equal tempered or meantone division. A capella singing does ensue some variation in pitch classes, but still some particularities can be described: although diverse interval sizes, three nearly fifths are present in the scale. One of these fifths is built by two thirds that resemble a pure minor third and a pure major third (that lies between the intervals $168+210=378$ cents). Thirdly,

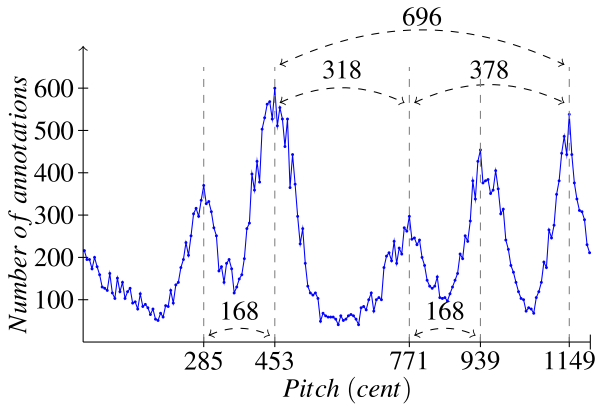

Figure 3. This song uses an unequally divided pentatonic tone scale with mirrored intervals 168-318-168, indicated on the pitch class histogram (horizontal axis visualizes the octave reduced view). Also indicated is a near perfect fifth consisting of a pure minor and pure major third.

an interesting mirrored set of intervals is present: 168-318-168. This phenomena has been encountered several times in the RMCA archive: a scale that is constructed around a set of mirrored intervals. It could be a (unconscious) cognitive process to build a scale around such set of mirrored intervals, but makes it also more convenient to perform for human voice.

3.2. Microtonal composition

Harry Partch, Ivor Darreg, and composers from spectral music really devoted their oeuvre to aspects of microtonality. As a tribute, a composition from Darreg is analyzed here as an example. Tarsos has analyzed and rebuilt the scale that was used in track five from Detwelvulate! *'From beyond the Xenharmonic Frontier'*. This composition uses an equal temperament of 9 tones per octave as

Note	C		D		E		F		G		A		B		C
Pythagorean Tuning		204		204		90		204		204		204		90	
Ptolemaic Tuning		204		182		112		204		182		204		112	
Mean-tone Temperament		193		193		117		193		193		193		117	
Werckmeister I		192		198		108		198		192		204		108	
Equal Temperament		200		200		100		200		200		200		100	

Table 1. Diatonic overview of several historical tuning systems. All interval values are expressed in cents.

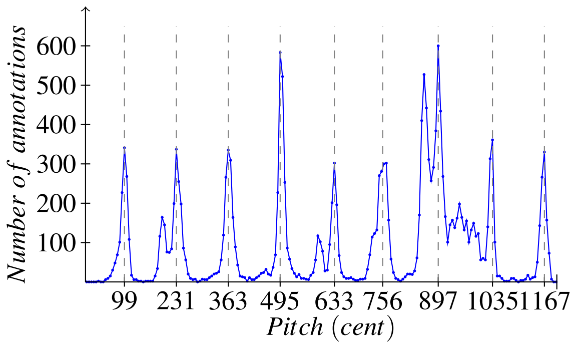

Figure 4. This composition contains an equal temperament of 9 tones per octave

can be seen in Figure 4. Each interval counts 133 cents, which entails the occurrence of 9 major thirds and 9 augmented fifths in the scale as well. It provides the piece a scale that is built on a mixture of unknown and more familiar intervals. However Tarsos did retrieve all nine pitch classes, also three small deviations of pitch classes were noticed. Each of these three pitch classes measure consequently 38 cents lower then the three notes from the intended scale (namely 231 633 and 897 cents). They occurred in a specific octave, and not over the entire ambitus. More research could tell the intention of these tones.

3.3. Historical scales

One can upload any of the historical scales that is listed in Scala, or made manually, and convert any classical symbolic score available in MIDI into audio. As for example Bach's Das Wohltemperierte Klavier, BWV 846-893, can be listened to in equal-temperament or in well-temperament. Interesting opposition since there is still a discussion on which tuning Bach intended these compositions for[5]. Another use case is rendering some baroque compositions, that are known for their sensitivity towards affective theory, in several tuning systems. As a teaser, table1 gives an overview of some historical tunings. Notice the small variations in the different diatonic scales.

4. TARSOS LIVE

Tarsos can be used real-time: when this option is selected, any tone or set of tones that is presented is directly analysized. The scale that is played arises on the graphical axes. By selecting the peaks of the annotations, the program allows you to play together with the live musician in that specific scale. Many possibilities come forward, an interesting one is that Western classical musicians can now play together with any scale that is presented by musicians, ranging from alternative scales to ethnic instruments. Any alteration in the scale is noticed directly, and can the scale can be adjusted.

5. FUTURE WORK

The interface of Tarsos will be provided with a scale visualization that does not refer to the Western keyboard and that comprises the size of the intervals as an ecological user interface. Another feature will be the display of non-octave bound organisation of scales, as for example the 88CET or Bohlen-Pierce. Where the user can (re)set the interval of the octave towards any personal choice. Tarsos will be applied on the entire RMCA archive intending a better insight in African tone scales.

6. REFERENCES

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