Analysis, DSP and Composition

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Abstract. This paper presents the process of a musical composition (Resemblance) based on the analysis of children's songs and the use of the results of this analysis to produce a new work using Neural Nets, Artificial Inteligence, Grammars and Digital Signal Processing.. The idea of the composition came from the theory enunciated by Noam Chomsky that indicates how children recognize timbre and contour of melodic songs before semantic meaning of language, as well as the consideration of music as natural language. The concept of music as natural language allows the use of concepts and algorithms derived from Computer Science and Artificial Intelligence.

Keywords: Musical Analysis, Resynthesis, Audio DSP. Csound Composition

1 Introduction

Resemblance is a piece designed as homage to Charles Dodge[1] and it is related to voice analysis processing and computer music composition. [2]

The basic material came from children songs and from the ideas of Noam Chomsky [3] that describes that the contour and melodic patterns of these songs are very similar all over the world.

The Basic elements used in Resemblance are:
Spanish children's songs
Female voice
Sinusoidal sound and
DSP with these elements

2 Composition Preparation

The composition process is based on data acquisition, processing of these data validation of the result and correction of input parameters.

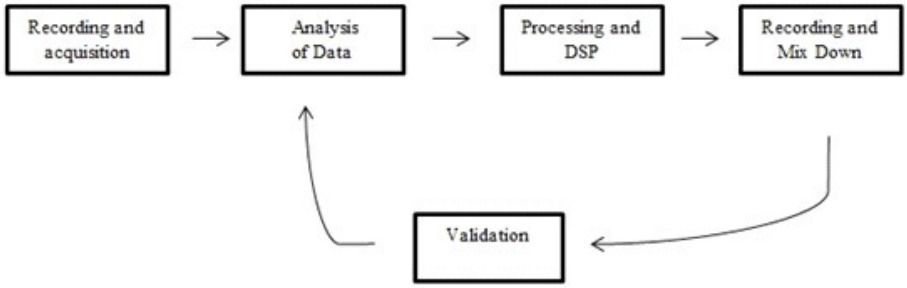

Figure 1. Flowchart

2.1 Data Adquisition

The analysis of the data and the use of Machine learning can give us algorithms to create new material.
The first task is the recording of popular folk songs. This recording was realized in at early Education school in Madrid (Spain).
The second task is the analysis of data related to this songs recorded with children's songs.
Aspect to be analyzed are frequency, amplitude, duration, contour of segments, resonances frequencies and coefficients to be applied at resonant filters, etc.

Table 1

Frame	Frequency	Amplitude	Duration	Formants	Resonances
N1	F1 Hz	A1 dB	D1 sec	Hz	Hz
N2	F2 Hz	A2 dB	D2 sec	Hz	Hz
N3	F3 Hz	A3 dB	D3 sec	Hz	Hz
N4	F4 Hz...	A4 dB	D4 sec	Hz	Hz
...					

2.2 Musical Analysis

The piece requires an analyis of basic elements in music theory [4]
Pitch Perception
Rhythm Perception
Contour [5]

These parameters give us information to be able to shape the work

Table 2

scale					
Dyatonic	d1	d2	d3	d4	d5
Chromatic	c1	c2	c3	c4	c5
Contour	+	+	-	+	-

2.3 Structural Analysis

This study offers the general structure of the entire song giving the sequences of melodic patterns as well as the phrasing and sections of the composition [6]

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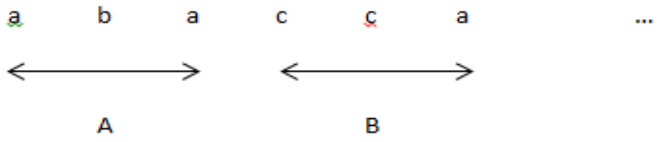

Figure 2. Cells and sentences

2.4 Physical Analysis

Csound allow the analysis of physical elements from the audio source.
The elements of the new generation of the music composition came from
Cepstrum and Mel Coefficients
Coefficients from LPC technique
Phase and Amplitude of harmonics and formants

3 Composition Process, DSP and Final Mixing

The analysis of the signal give a group of parameters and a data set used to transform and generate new material based in the original source of the composition.
The parameters from the analysis can be changed and these parameters are subjected to a controlled variation by means of random functions, mainly Gaussian.
These variations must be subject to a control between certain limit values. This allows a result that has musical and aesthetic validity as well as the changes produced with these variation are also a recognizable with the sources of the original source.
The methodology adapted from Artificial Grammars and NN give some possibilities that must be chosen by the composer according to musical aspects

of music composition and according to the idea of elementary melody, rhythm and contour contained in the original children's songs.

Figure 3. Code and Decoding parameters

4 C-Sound

Resemblance is a composition based on analysis of pitch, contour, rhythm, structure of cells and motives.
After this analysis computer software is used to resynthesize and transforms the original source of audio material.
Resemblance uses facilities of Csound for almost the entire design and production of the piece.
Csound can helps a composer to do Analysis, Synthesis, Re-synthesis, DSP and have facilities to help in the process of composition of a piece.
The process of Composition Asisted by Computer, CAC or CAO, uses election and distribution of pitches , analysis and re-synthesis of audio files, DSP of sound files and final distribution over time and space.
The main basic opcodes used in this piece are described in the next section.

4.1 Examples of opcodes and utilities for Analysis, re-synthesis and DSP inside Csound

4.1.1 A first and basic operation is to find information abour the recording of original audio file
Sndinfo Displays information about a soundfile.

```
csound -U sndinfo [options] soundfilenames ...
sndinfo [options] soundfilenames ...
```

4.1.2 Use of original recording: Space and Filtering
reson
reson — A second-order resonant filter.

```
ares reson asig, xcf, xbw [, iscl] [, iskip]
```

space — Distributes an input signal among 4 channels using cartesian coordinate

```
a1, a2, a3, a4  space asig, ifn, ktime, kreverbsend, kx, ky
```

4.1.3 Manipulation of original audio files
tableshuffle — shuffles the content of a function table so that each element of the source table is put into a different random position.

```
tableshuffle ktablenum
```

```
tableshufflei itablenum
```

bbcutm — Generates breakbeat-style cut-ups of a mono audio stream.

```
a1 bbcutm asource, ibps, isubdiv, ibarlength, iphrasebars,
inumrepeats \
 [, istutterspeed] [, istutterchance] [, ienvchoice ]
```

random — Generates a controlled pseudo-random number series between min and max values.

```
ares random kmin, kmax
ires random imin, imax
kres random kmin, kmax
```

randomh

randomh — Generates random numbers with a user-defined limit and holds them for a period of time.

```
ares randomh kmin, kmax, xcps [,imode] [,ifirstval]
kres randomh kmin, kmax, kcps [,imode] [,ifirstval]
```

loops

```
idurloop random 1, 4; duration of each loop
idurins random 1, 5; duration of the triggered instrument
ipan random .2, .8; random panning between left (0) and right (1)
```

4.1.4 analysis of audio file

lpanal — Performs both linear predictive and pitch-tracking analysis on a soundfile.

```
csound -U lpanal [flags] infilename outfilename
lpanal [flags] infilename outfilename
```

pvanal — Converts a soundfile into a series of short-time Fourier transform frames.

```
csound -U pvanal [flags] infilename outfilename
pvanal [flags] infilename outfilename
```

4.1.5 DSP and Re- synthesis

pvoc — Implements signal reconstruction using an fft-based phase vocoder.

```
ares pvoc ktimpnt, kfmod, ifilcod [, ispecwp] [, iextractmode] \
[, ifreqlim] [, igatefn]
```

lpread — Reads a control file of time-ordered information frames.

```
krmsr, krmso, kerr, kcps lpread ktimpnt, ifilcod [, inpoles] [,
ifrmrate]
```

cross2 — Cross synthesis using FFT's.

```
ares cross2 ain1, ain2, isize, ioverlap, iwin, kbias
```

4.1.6 Writng files and distribution

The final option is to write an audio file in wav or the chosen format and distribute the sound over space an time
Write audio file
`-o WriteToDisk1.wav -W`

vbap — Distributes an audio signal among many channels.
ar1[, ar2...] **vbap** asig, kazim [,
kelev] [, kspread] [, ilayout]
array[] **vbap** asig, kazim [,
kelev] [, kspread] [, ilayout]

spat3d
`spat3d - Positions the input sound in a 3D space and allows moving the sound at k-rate.`
aW, aX, aY, aZ **spat3d** ain, kX, kY, kZ, idist, ift, imode, imdel, iovr [, istor]

Examples of code are very easy to write following the advice of the Csound Manual and several opcodes help inside Csound Qt and/or other distributions Exmpls can be foind in Boulanger [7], McCurdy[8], Bianchini[9], Di Liscia[10], etc

5 Conclusion

Resemblance is a electronic piece composed after an analysis of previous material and the use of this analysis to resynthesize the sonority of previous music composition.
It uses theories and concepts derived from other disciplines and ca be seen as an example of Computer Aided Composition.
CAC/CAO and the use of algorithms derived from AI and Machine Learning and represent a main path in the music scene all over the world.
These processes give the composer a chance to listen and see several solutions and try new solutions with a change of parameters.
Software is changing every second and new possibilities are open to the composer and new technology advances offers the possibility to have a real time response in live concert option. Nevertheless, aesthetic, history and musical parameters need always to be considered in the period of analysis and evaluation of learning in Neural Nets as well as in the final presentation of a new work.
This idea needs algorithms to have control and evaluate the final result of the composition.
Csound, presented by Vercoe in the 80s is a general software with a lot of opcodes written over time and helps with analysis , processing and the process of CAC.

References

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