The *Six Fantasies Machine – an instrument modelling phrases from Paul Lansky's* Six Fantasies

Andreas Bergsland
Dept. of music, NTNU
7491 Trondheim
Norway
andreas.bergsland@ntnu.no

ABSTRACT

The *Six Fantasies Machine* (SFM) is a software instrument that simulates sounds from Paul Lansky's classic computer music piece from 1979, *Six Fantasies on a Poem by Thomas Campion*. The paper describes the design of the instrument and its user interface and how it can be used in a methodological approach called *the epistemology of simulations* by Godøy. In *imitating* phrases from Lansky's piece and enabling the creation of *variants* of these phrases, the user can get an experience of the essential traits of the phrases. Moreover, the instrument will give the user hands-on experience with processing techniques that the composer applied, albeit with a user-friendly interface.

Keywords

LPC, software instrument, analysis, modeling, csound

1. INTRODUCTION

The Six Fantasies Machine (SFM) was developed as a part of my doctoral project, *Experiencing Voices in Electroacoustic Music* [1]. Here, I establish a framework for understanding and describing the listener's experience of voices in acousmatic electroacoustic music and related genres. The framework is then applied in evaluating and describing Paul Lansky's classic computer music work from 1979, *Six Fantasies on a Poem by Thomas Campion.* In addition to using this framework, which is largely based on a phenomenological and introspective methodology, I also explore how variations of the musical phrases appearing in the piece affect the listening experience.

The SFM was developed to imitate or simulate the phrases appearing in the piece, but also to be able to synthesize variants closer or further from the original phrases, and to explore how such variants can affect the experience. This paper will briefly discuss the theoretical context of my overall methodology. Furthermore, I will describe relevant features of Lansky's work and its composition process, before giving a more detailed explication of the technical layout and user interface of my instrument. Subsequently, I will show how the instrument has come to use in my project, and finally point to other uses of the instruments and possible ways to develop it further.[1]

[1] The SFM instrument and the thesis are available for download at http://folk.ntnu.no/andbe/Projects.html

2. EPISTEMOLGY OF SIMULATIONS

In his dissertation Godøy has developed the notion of the *epistemology of simulations* [2]. By this, he refers to the possibility of creating variants of a sound event or object where a certain trait or aspect is changed while others remain the same, and then *observing* and *comparing* the effect that this has on the experience. This is seen as a means of seeing what constitute the essential traits of musical objects. The epistemology of simulations is usually at work in the paradigm of synthesis, Godøy argues, because synthesis usually involves interplay between *listening* to the sound and, by trial and error, *tuning* the synthesis model and its parameters so as to achieve the desired result. However, Godøy also suggests that this approach could be applicable in the investigation of musical objects on a larger scale, such as phrases in a musical work. There have been some examples of studies that use a methodology not too far from what Godøy suggests.

Firstly, Michael Clarke has developed an interactive software tool for analyzing Jonathan Harvey's computer music work *Mortuos Plango, Vivos Voco* [3]. The software is meant to aid listeners in their exploration of the composition by allowing them to recall specific locations from the work and to juxtapose these, but more interesting in this context is that it also allows for interactive exploration of the synthesis and processing techniques used in the piece. Clarke argues that since such techniques are often a part of the individual work, it is important for someone wanting a deeper understanding of the music to clarify the components of the compositional technique. Trying out the techniques in an interactive manner might learn the user more about the potential of the techniques so as to place the compositional choices made by the composer in a wider context of possibilities [4].

Secondly, Keller and Ferneyhough develops what they call *analysis by modeling*, in their study of the temporal quantization processes and the streaming-fusion processes in Xenakis's *ST/10-1 080262*, one of the first computer-generated algorithmic compositions [5]. The stochastic algorithms of this piece is implemented by the authors in *Patchwork* (IRCAM), thus opening for a number of different realizations of the piece. This is then used to investigate temporal quantization and streaming-fusion processes at work in perception.

In that way, both approaches have many similarities with Godøy's notion of an *epistemology of simulations*, albeit in somewhat different ways. While Clarke's approach stresses the pedagogical and hermeneutical goals in developing a tool for simulating musical objects, Keller and Ferneyhough focus more on particular aspects of perception and how these are affected by manipulating the parameters of the model. I will show in section 5 that the SFM instrument has components from both these approaches.

3. LANSKY'S *SIX FANTASIES*

3.1 Compositional idea and layout

As the full title suggests, *Six Fantasies* is based on an untitled poem by the English Renaissance poet Thomas Campion (1567-1620), published in his treatise *Observations in the Art of English Poesie* in 1602 [6]. In accordance with many so-called text-sound pieces, the recitation of the poem is recorded, and with few exceptions the recorded recitation constitutes the sound source material for the whole piece [7]. In the five first movements of the composition, entitled *her voice*, *her presence*, *her reflection*, *her song* and *her ritual*, the recitation is manipulated and temporally modified so as to create different sonic manifestations of the poem. The original reading is then presented in the last movement, *her self*, accompanied only by synthetic sounding stretched out vowels.

3.2 Technical procedure

The main technique that Lansky applied in this piece was Linear Predictive Coding (LPC), developed during the 1960s and 70s, mainly to compress speech signals [8, 9]. Greatly simplified, the LPC *analysis* of the speech signal makes an estimation of the time-varying filter component, the fundamental frequency of the phonation component, the intensity of the signal, and whether the signal is voiced or un-voiced, i.e. noisy [10]. In the *resynthesis* process, the error signal from the analysis is used to decide whether to synthesize a buzz signal (pulse-train) for the voiced parts, or white noise for the un-voiced part. The appropriate signal is then controlled by the analysis parameters for intensity (buzz and noise) and fundamental frequency (buzz only). The resulting source signal is then fed through a time-varying filter controlled by the analysis parameters, so as to create a synthesized approximation of the speech signal. By changing the analysis parameters, it is possible to manipulate the source component, in particular fundamental frequency (f0) and intensity, independently of the filter component. Since the analysis is made on a frame-by-frame basis, it is also possible to vary the frame rate in the re-synthesis process, thereby changing the playback speed without affecting pitch or spectrum. This enabled Lansky to transform the recitation in different ways and to different degrees; transposing, inverting, flattening, exaggerating or fully "sculpting" the intonation contour, time-stretching the signal and replacing the buzz with noise.[2] The reading/speaking voice could be thereby be transformed into what sounded like a kind of singing (as in *her song*), a vocal style between speech and song (as in *her presence*), and whispering (as in *her ritual*). Lansky also implemented a "chorus" effect by using several pulse generators together with small random variations in fundamental frequency, hence creating a richer sound [Lansky, personal communication].

In addition to the LPC technique, Lansky also applied comb filters extensively in *her reflection* and *her ritual*. Each comb filter, which is commonly implemented as a delay with feedback added to the original signal, adds a resonance at a particular frequency depending on the delay time and amount of feedback. By using banks of many double comb filters, Lansky could produce rich resonances, often with a chord-like flavour. By setting the delay time higher, however, Lansky could create more typical delay effects, as in *her reflection*. A small amount of reverberation can also be heard in several of the fantasies.

[2] The possibility of shifting the spectral envelope (i.e. the filter component) that LPC offered, however, was only applied in the accompaniment of *her self*.

4. THE SFM INSTRUMENT

The SFM instrument is developed in the script based synthesis and processing environment *csound* [11]. This environment was used both to implement the signal processing parts as well as the graphical interface (GUI). It has been developed and tested for Windows XP, but should in principle be possible to run on other platforms with minor adjustments.

Although the SFM instrument produces vocal phrases that are similar to those that can be heard in Lansky's piece, they are *not* based on the same vocal material. Having no access to Lansky's original LPC files nor to his sound files, I have instead used an actress to imitate the original reading as it is presented in *her self*. The recording of her reading was then resampled to 14 kHz, the same as Lansky originally applied, analyzed with the LPC analysis utility in *csound*, LPANAL, and used as a basis for the LPC-resynthesis. Lastly, SFM is in its current version equipped with 8 voices, which can start simultaneously or with a delay of up to 10 seconds.

4.1 Resynthesis and processing

SFM uses the same standard implementation of the LPC resynthesis as in *Six Fantasies*. A conditional statement assessing the error value from the appropriate analysis file read by the `lpread` opcode decides whether a voiced (`buzz`) or an unvoiced noise source (`rand`) is passed through a time-varying filter (`lpfreson`).[3] A scaling value that crossfades between the buzz and the noise signal also enables blending the buzz and noise signals, or sending only noise through the filter.

The time-pointer, with which the analysis file is read, is divided into six segments, and the break-points defining these segments are editable by the user. By multiplying the duration value of each these segments with a factor, independent time-stretching/compression of segments can be achieved.

While the analysis file provides pitch and amplitude analysis of the signal which can be used to control f0 of the `buzz`-opcode, the instrument also gives possibilities of either manipulating the values from the analysis or setting them independently. A scaling value weighs the values from the analysis file against those provided by the user, thus enabling an intermediate situation between these two. The f0 values can be multiplied with a factor and thereby transposed. Moreover, by scaling the deviation around a calculated mean f0, the f0 contours can be flattened, exaggerated and/or inverted. The f0 values can also be set independently for each of the segments, and by applying a low-pass filter the length of the glide between the static f0 values can be adjusted. A mechanism for tuning the user provided f0 values into the tempered scale is also implemented in the instrument.

The `lpfreson-`opcode opens for shifting the frequencies of the filter up or down, so as to transpose the spectral envelope and the vocal formants of the resynthesized sound. A small amount of band pass filtered noise is also added to the buzz source to prevent a "buzzy" quality and thereby increase naturalness. Moreover, "chorus" is implemented as an optional feature, mixing the original signal with the output of four additional buzz sources with small random pitch variations (+/- 0.8%).

The resynthesized signal is then fed through an instrument implementing a bank of 9 double comb filters per voice, making it possible to use up to 72 comb filters simultaneously. Finally, the signal passes through a reverberation instrument before it is sent to the output.

[3] A simplified flow chart of the instrument is available at: http://folk.ntnu.no/andbe/Projects.html#SFM-Flowchart

4.2 GUI

The user interface is implemented with the Fast Light Toolkit (FLTK) opcodes in *csound*. A snapshot of the whole interface is shown in Figure 2. The interface is split into two sections, the *voice section* and below it, the *mixing section*. The *voice section* contains the controls for the eight individual voices, ordered as tabs. At the bottom left of the section, the user can choose between the 21 available LPC analysis files, which contain the vocal phrases of the poem. Choosing a file will at the same time show the appropriate text and the duration of the file. At the top left of the section, the user can set the seven break points that define the six segments of the analysis file.

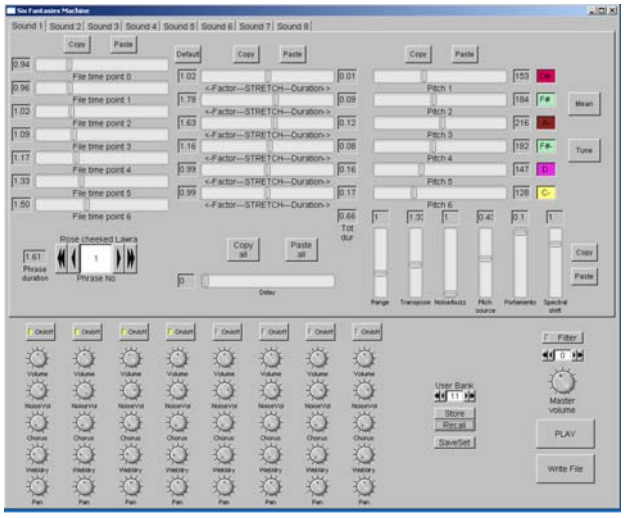

Figure 2. SFM GUI with *voice section* at the top and *mixing section* at the bottom.

These segments can then be time-stretched or compressed using the stretch factor controllers in the middle. The stretch factor values as well as the duration of the segment will show up in number boxes next to the sliders, and the latter will be summed to display the total duration of the phrase.

At top right of the section, pitch/frequency for each of the six sections can be set (see figure 3 for details). Here, the pitches closest to the frequency values chosen will turn up in a colored window next to the slider, with different colors for each pitch. "+" and "-" indicate whether the pitches are slightly high or low. Pressing the "Tune" button will then set all the chosen frequencies to correct tempered pitches, thus removing any "+" or "-" signs. The "mean" button will set the sliders to the mean f0 of the analysis file. The lower right part of the *voice section* contains sliders for setting f0 *range* (scaling of deviation around mean f0), *transposition*, *noise/buzz mix* of the source signal, *portamento* (glide) time between consequent f0 values set by the user, and *spectral shift*. At bottom centre the time delay of the voice can be set. For easy transfer of values between voices, copy and paste buttons are provided for both slider groups and for all the voice controls.

The mixing section in the lower part of the interface is split in three parts. To the left, there are eight mixing "stripes" for each of the eight voices, with "on/off", volume, noise level, chorus, reverb and pan controls. To the right, the user can press a button to activate the comb filter instrument and choose between filter presets. The setting for the comb filters can in the current version be edited by opening accompanying text files in a spreadsheet editor. Below the master volume, there are

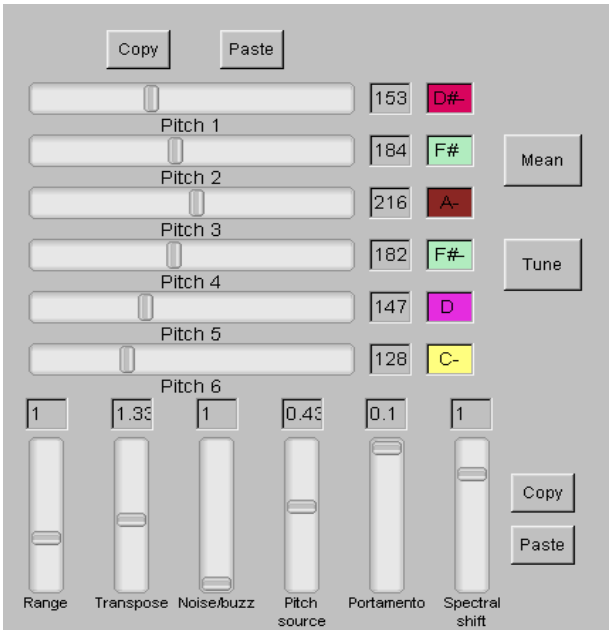

Figure 3. SFM GUI detail from *voice section*

buttons for playing back the phrase with the current setting and for writing this to a sound file. Finally, between these sections there are buttons for saving and loading presets.

5. USING THE SFM

Since the SFM was developed as a tool aiding an epistemology of simulations, creating imitations of phrases from Lansky's piece and varying these has been my main focus area. However, I have also found that the instrument can be used as a tool for creating sound material for new compositions. As in Clarke's project on *Mortuos Plango* all these ways of using the instrument can give its user a better understanding of the techniques used by Lansky when composing *Six Fantasies*. I will address these areas of use in turn.

5.1 Imitations

Creating vocal phrases that are relatively similar to phrases in *Six Fantasies* has been one important goal in the process of developing the instrument. Without sufficiently similar sounding results it would be very difficult to establish the link to Lansky's piece. In its current form, I experience that this link is indeed present, and this is confirmed by others who had heard the results, including Lansky himself. After having worked extensively with a selection of phrases that I wanted to imitate I have come to the following conclusions:

- Phrases from most movements can be imitated fairly well.
- Many of the phrases in *her ritual* have been difficult to imitate due to limited possibilities for repeated triggering.
- Factors as a) using another voice than in the original piece, and b) not knowing anything about the spectral characteristics of the recordings used to create Lansky's LPC-files, have delimited the degree of similarity that can be attained.
- Imitating the phrases has facilitated a fine tuning of perception, thus giving access to minute details of the piece.
- Making the SFM has given me an increased understanding of the technical challenges and sounding results of both LPC and comb filters as well as Lansky's compositional process.
- The lack of precise parameter control due to a limited number of sliders makes the imitations less similar than when controlling the parameters via a text-based score file. Still,

the lack of user-friendliness in editing parameters as text makes it an alternative only for the particularly interested.

In the current version, ten of the imitations that I have made are included as presets in the instruments.[4] New users will probably also learn something about Lansky's piece both by looking at the imitations included in the presets and by trying to create new imitations from scratch.

5.2 Variations

Starting from the imitations, one can create many types of variations of the phrases, which allow the user to learn how the different control parameters can affect the sound. In particular, it can be interesting to:

- decompose the phrases into individual voices
- add new voices, e.g. in new transpositions, with flattened, exaggerated or inverted pitch trajectories
- stretch or compress shorter segments or whole phrases
- change one or several pitches in phrases which are controlled from the pitch sliders
- modify the resonant frequencies or the decay times of the comb filters where these are applied

Playing with such variations and comparing them to the original phrases and/or their imitations may then make the user experience that there are limits to the degree of modifications that can be applied before the phrases turn into "something else". Thus, such experiences can give a sense of what makes the phrases what they are – in other words the "essential traits" that Godøy talks about (see section 2).

5.3 Exploring aspects of listening

Working with my PhD project, the epistemology of simulations has been one of several methodological strategies to help establish a framework for describing and understanding the experience of voices in electroacoustic music. The SFM instrument is one of several tools that have demonstrated in what ways different control parameters can affect different aspects of the experience, for instance: a) the directing of attention towards different aspects of the vocal phrases, such as verbal semantic, affective or identity related aspects, b) information density, c) naturalness/artificiality, d) salience, or e) stream integration/segregation.

5.4 Composing

The most enjoyable way of using the instrument is probably playing freely with parameters to create results that are sonically interesting, be they closer or farther from the phrases in *Six Fantasies*. These phrases can then be written to file and used as sound material for electroacoustic works of music.[5] Working with the instrument in this way will probably also expand the users' knowledge of, and a feeling for, the sonic results produced by the LPC resynthesis, the comb filters and the other parameters. Thus, it might still indirectly increase the users' understanding of the tools applied by Lansky in his original composition, even though the interface facilitates a much more accessible means of creation and modification.

6. FUTURE DEVELOPMENT

There are several features of the SFM instrument that have room for improvement in future versions:

- Increase the number of voices
- Implement widgets for controlling the comb filter parameters in the GUI.
- Increase the number of comb filters in the instrument.
- Increase the number of pre-made presets, as well as the number of presets available for editing by the user.

Currently, I am also considering creating a GUI for the instrument in *Max* by using the *csound~* external written by David Pyon [12,13]. This opens up for letting the user work with the pitch contours graphically through the *multislider* object, thus making it possible to see and edit the pitch contours with the same interface. Porting the GUI part of the instrument to *Max* also opens up for other interesting possibilities. By adding text, pictures and video one could develop an interactive multimedia pedagogical tool that approaches for Lansky's *Six Fantasies* what Clarke did for Harvey's *Mortuos Plango*.

7. CONCLUSION AND FUTURE WORK

The SFM instrument can in its current version be used in an *epistemology of simulations* approach, as Godøy delineated. Thus, the instrument can be a valuable tool in guiding a user towards an expanded understanding of Lansky's *Six Fantasies* through active exploration. In particular the instrument can give the user hands-on experience with signal processing techniques the composer used, albeit with a user-friendly interface. I have also shown how the instrument can also be used to illustrate experiential aspects of voices in electroacoustic music. Lastly, the SFM instrument can itself be applied as a compositional instrument for composers and sound designers interested in exploring the sound world of techniques which in today's musical world might seem obsolete and outdated, but which nevertheless provides a sonically rich palette of expressions.

8. REFERENCES

[1] Bergsland, A., *Experiencing Voices in Electroacoustic Music*, in *Dept. of Music*. 2010, NTNU: Trondheim.

[2] Godøy, R.I., *Formalization and Epistemology*. 1997, Oslo: Universitetsforlaget, 295-296.

[3] Clarke, M., *Jonathan Harvey's Mortuos Plango, Vivos Voco*, in *Analytical Methods of Electroacoustic Music*, M. Simoni, Editor. 2005, Routledge: New York. p. 111-143.

[4] Clarke, M., *An Interactive Aural Approach to the Analysis of Computer Music*, in *International Computer Music Conference*. 2005: Barcelona, Spain.

[5] Keller, D. and B. Ferneyhough, *Analysis by Modeling: Xenakis's ST/10-1 080262*. Journal of New Music Research, 2004. 33(2): p. 161-171.

[6] Campion, T., *Observations in the art of English poesie, 1602*, in *A defence of ryme against a pamphlet entituled Obseruations in the art of English poesie, 1603*, G.B. Harrison, Editor. 1966, Barnes & Noble: New York.

[7] Ondishko, D., *Six Fantasies on a Poem by Thomas Campion: Synthesis and Evolution of Paul Lansky's Music Compositions.* 1990, Eastman School of Music: Rochester, New York.

[8] Atal, B.S., *The History of Linear Prediction.* IEEE Signal Processing Magazine, 2006(March): p. 155-161.

[9] Atal, B.S. and S. Hanauer, *Speech Analysis and Synthesis by Linear Prediction of the Speech Wave.* The Journal of the Acoustical Society of America, 1971. 47(2B): p. 637-655.

[10] Lansky, P., *Compositional Applications of Linear Predictive Coding*, in *Current Directions in Computer Music Research*, M.V. Mathews and J.R. Pierce, Editors. 1989, MIT Press: Cambridge, Mass. p. 5-8.

[11] Boulanger, R., ed. *The Csound Book*. 2000, The MIT Press: Cambridge, Mass.

[12] http://cycling74.com/products/maxmspjitter/

[13] http://davixology.com/csound~.html

[4] Available online at http://folk.ntnu.no/andbe/Projects.html.

[5] One short "etude" made by this author is available at http://folk.ntnu.no/andbe/Projects.html.