GranScore: a granular synthesis specialized graphic score to analyze and edit electroacoustic music at multiple time scales.

COMUNICAÇÃO.

Fernando Falci de Souza
Instituto de Arte (IA) e Núcleo Interdisciplinar de Comunicação Sonora (NICS)
Universidade Estadual de Campinas (UNICAMP) - fernando_ffs@yahoo.com.br

Adolfo Maia Jr.
Instituto de Arte (IA) e Núcleo Interdisciplinar de Comunicação Sonora (NICS)
Universidade Estadual de Campinas (UNICAMP) – maia.adolfo@gmail.com

Abstract: We present the main characteristics of graphic scores mainly those ones for electroacoustic music, computer aided music and audiovisual installations. We review briefly the concepts of Graphic Scores, Granular Synthesis and present ***GranScore***, software specifically designed for the sound domain of granular synthesis, which can be useful for electroacoustic and mixed composition, and for educational purposes.

Keywords: granular synthesis. graphic score. audiovisual.

GranScore: uma partitura gráfica especializada em síntese granular para editar música eletroacústica em múltiplas escalas de tempo.

Resumo: Apresentamos as principais características de partituras gráficas, principalmente as destinadas a música eletroacústica, composição auxiliada por computador e instalações audiovisuais. Revisamos brevemente os conceitos de partituras gráficas, síntese granular e apresentamos **GranScore**, um software projetado especificamente para o domínio sonoro da síntese granular o qual pode ser utilizado como uma ferramenta digital para composição de música eletroacústica e mista e com fins educacionais.

Palavras-chave: síntese granular. partitura gráfica. audiovisual.

1. Graphic Scores

We are now in a very exciting age for both professional and dilettante musicians. Due to the power of computers, the digital technology and the sophistication of software we can simulate complex phenomena of nature, solve intricate mathematical problems and perform creative tasks, which were unthinkable some years ago. This is also true for music processing, composition and performance, and particularly for the subject we want to discuss below, namely, graphic scores.

In a very broad sense Graphic Scores are instances of so called data *sonification*, which is a mapping taking visual objects (from a visual data space) to sound objects, which, in turn can be thought as elements of a sound data space. In principle, these mappings can be completely arbitrary. Nevertheless good and useful mappings can be difficult to find, depending on the nature of both visual and sound objects and the amount of them to be mapped into one another. So a more deep analysis of the two collections of objects is, in general, needed in order to get a suitable mapping as mentioned above.

The idea of Graphic Scores as tool for sound design and composition can be tracked to Norman McLaren's animations. McLaren created beautiful animations artfully synchronized with suitable music/sound tracks. Today is very common we find "scrolling scores" in YouTube, for example. Some of them are very impressive and skillfully worked and can be very useful for music education.

In the same way we can mention the classic visualization of the electroacoustic Ligeti's work *Artikulation* and its visual score created by Rainer Wehinger (LIGETI, 1958). It is commonly presented as an "aural score", that is, a score created from the aural impressions of Wehinger, but also in the sense that the listener can nearly "follow" the sound stream synchronized with the visual score (film). Nevertheless, although these were important works from the past, the more interesting with our present day technology, is the inverse process, that is: how can we get sound information from a time sequence (stream) of visual objects? Or, in other words, how we can create a dynamical and interactive score? This is what we mean as *sonification*. This is not a recent concept. In fact, as early works in the area we can mention Xenakis's *UPIC System* in which a user can compose electroacoustic music just drawing on a tablet coupled to a computer for processing (MARINO et all, 1993). These drawings are linked to a waveforms library. With this system Xenakis composed his electroacoustic piece Mycenae-Alpha (1978). In more recent times this work have inspired a number of other sonification systems such as *Iannix*, *Hyperscore*, *HighC*, Music Sketcher among others, which can be found in internet (THIEBAUT et all, 2008).

The idea of a graphic score can be advantageous for the modern composer since it can provide an intuitive and fast way to experiment several possibilities outputs for music composition. Of course when the sound space is limited to a convenient type of sounds, suitable algorithms can be properly developed in order to get a best friendly visual interface. In our case we restrict ourselves to so called granular sounds firstly proposed by the Dennis Gabor in 1947. So, our system *GranScore* is more suitable to control granular streams with its multiple two-dimensional parameter spaces. This work is a preliminary study of a graphic score to the particular space of granular sounds, although the interface and algorithms proposed here can be easily applied to more general set of sounds.

2. Granular Synthesis

Granular Synthesis is a digital technique of music composition whose physical and mathematical foundations are inspired on the theory of the Acoustic Quantum proposed by the Nobel Prize physicist Dennis Gabor (GABOR, 1946, 1947). This theory shows that sounds of any complexity and duration can be decomposed into a set of sound units named "grains of sounds" or "granular sounds," so that, theoretically, the original sound can be obtained through a re-synthesis process. Gabor showed that, formally, any sound could be represented mathematically as a set of "acoustic cells" with simple spectral content and length of about 10 to 200ms (GABOR, 1946, 1947). The decomposition of original sound in terms of sound grains has the same paradigm of the Fourier decomposition in to sine waves with different frequencies, that is, basis of a Vector Space, in our case the Space of Sounds accessible to the human ear. Gabor's theories have inspired composers to perform the reverse process, that is, composing sounds, timbres and textures from the manipulation and sequencing of a large amount of sound particles of very short duration (THOMSON, 2004; ROADS, 1988).

The *musique concrete*, initiated by the work of Pierre Schaeffer for radio and film in the 1940s, changed the approach of music composition. The use of recorded sounds (and synthesized sounds) and processes of transformation of this sound material has become the central aspect of the sonic art (ROADS, 2001). The Greek composer Iannis Xenakis was the first one to use the term *microsound* to refer to musical works in which the composer controls the sound material in microtime as, for example, in his work "Concrete PH". In this composition, Xenakis reorganizes small slices of magnetic tape containing a recording (XENAKIS, 2001). Stockhausen also composed some works of granular nature, for instance, the piece "Kontact", in which he uses analog pulse generators to create sound grains (TISSOT, 2008).

Although it is possible to compose in microtime using analog technology or even acoustic instruments, granular synthesis is more idiomatic in the digital domain. Here we highlight the contributions of Curtis Roads. From the 70's, Roads conducted many musical experiments with granular synthesis creating a comprehensive taxonomy for classifying both types of grains as well as how to organize them. In his famous book Microsound, Roads presents the history and technique of granular synthesis resulting from his work and of other researchers by the year 2000 (ROADS, 2001). Barry Truax is another major contributor in the area, and has been a pioneer in experiments with granular synthesis in real time. Truax also presents an extensive use of granular synthesis in the composition of soundscapes (TRUAX, 1988, 1990).

Granular Synthesis, being used either to obtain new sounds, to musical compositions or soundscapes, presents often the same challenge. Since the basic materials of composition are sound particles of very short duration, thousands of these particles are necessary to compose a musical segment. Specifying values individually for each of the particles is a tedious task and often human impracticable. To overcome this difficulty, it is common in our digital age, to employ a mathematical or algorithmic model that realize an abstraction of sound synthesis parameters, that is, a high-level model allowing the user control the synthesis of a large number and variety of grains of sound through a small set of macro parameters. In DiScipio's models the control of sound synthesis is done via parameters imported of Fractals Models, Dynamical Systems and Chaos Theory (DISCIPIO, 1990). Maia and Miranda used Fuzzy and Markov Chains (MAIA e MIRANDA, 2005). Lombardo proposed graph Theory, as a model of control, and Valle (VALLE, 2003) and Genetic Algorithms were used in one of our systems named EVOGrain (SOUZA et all, 2009).

3. GranScore

In our current research we are looking for audiovisual correspondences that links grains of sound to grains of image (SOUZA et all, 2013). In some cases, in which the mapping from audio parameters to visual ones is very complex, the result leads to more artistic manifestations in the field known as *visual music*. In the other hand, when there is atomic correspondence between perceptive modalities, that is, for each grain of sound there is one exclusive visual object that represents it, and recursively the mapping between the internal parameters of each grain to the internal parameters of the visual representation is a simple one-to-one mapping; in this case, the audiovisual correspondence is more suitable to music analysis and composition (SOUZA, 2013).

As a test case of the later, we have developed the applicative *GranScore*, a graphic score that interacts with the GranularStreamer (SOUZA, 2009), a real-time granular synthesis sound engine, allowing an off-time visual analysis of the grains created during a performance. This interface is able as well to edit granular material and create new works from scratch. A grain of sound produced by GranularStreamer has the following set of parameters: *offset time, waveform frequency, duration, amplitude, waveform offset, and bi-dimensional spatial position.* In GranScore each grain of sound is represented by a visual object with the form of an ellipse whose color corresponds to the waveform frequency, its size to duration and its transparency to amplitude of the waveform. Of course, other geometric objects can be chosen and related to another type of grains or even more complex waveforms. These visual objects are plotted in a two-dimensional space with offset time variable as the x-axis and a customizable parameter as y-axis. Any parameter from the grain, except offset time, can be configured to be the y-axis of the score. In Fig.1 we can see the same segment of a piece, on the left the y-axis is frequency, on the right it is duration.

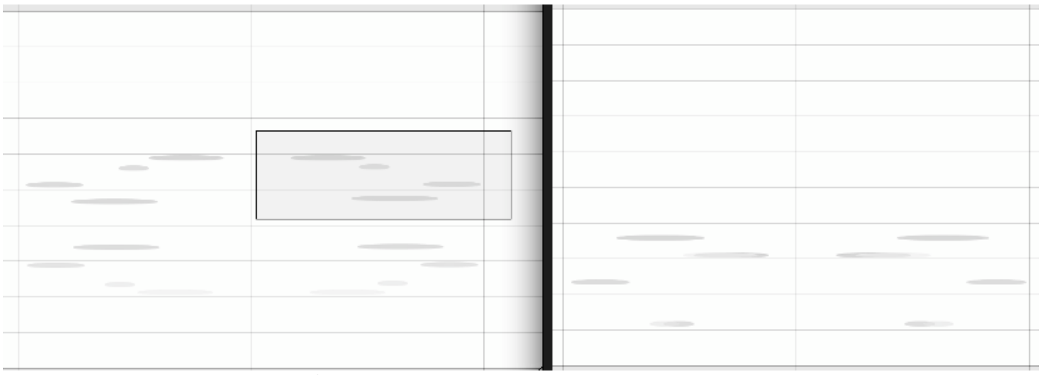

Figure 1: Two screen shots of GranScore showing the same grains at two distinct bi-dimensional parameters. Note the selection rectangle on the left hand screen shot with the chosen grains to be modified.

The user interacts with the system using mainly the mouse in three modes. The first one is a regular navigation function that scrolls the score right/left to displace time axis, and up/down in order to focus a specific region of the y-axis parameter. The second function of the mouse is the zoom tool that, although simple, is one the most powerful tool of the GranScore. With zoom tool the user can visualize and consequently analyze and work sound material from multiple time scales of sound, from the microsound layer up to the whole composition at once. In Fig.2, at the right hand side, we present a cloud of grains, a high level sound object, with a total duration one minute, while the other picture shows a detail from the middle of the cloud that lasts 500ms.

The third function of the mouse is the *select/edit* tool. With this tool the user is able to select some of the grains shown in the screen to perform modifications. It is possible to drag subsets of grains anywhere in the screen to change their offset time, as well the value of the parameter which is being plotted in the y-axis at the moment. The user can also use the arrows of the keyboard to perform a finer, very precise, control of the modification.

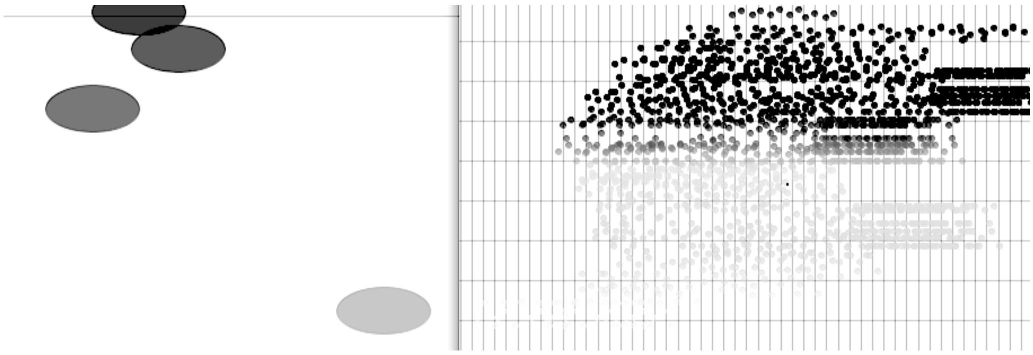

Figure 2: The zoom tool is the most important feature of the GranScore allowing the user to interact with sound material at multiple time scales.

Last but not least, at the keyboard the user also finds commands to copy and paste grains, delete grains, save the score, reset view configuration and to play a selected part or even the entire score (this last one requires the GranularStreamer). Therefore, *GranScore* has potential to be a very useful and flexible tool for electroacoustic or mixed composition and, as far as we know, it is an original graphic interface in its conception dedicated to Granular Synthesis.

4. Conclusions and Future Work

GranScore is a graphic score specialized for the domain of granular synthesis. Since it is specialized to Granular Synthesis, it presents many advantages. The zoom tool in combination with the select/edit tool allows the user to work the granular material with a high level of plasticity. At one end the user has the precision of selecting a single grain to change its parameters with precisions of tenths of milliseconds for duration or tenths of midicents (that is, one semitone divided in 1000 parts) for waveform frequency. While at the macrotime scale all the grains or any subset of them in the composition interface (window) can be selected at once to have their parameters altered. The system brings also a solution for the frequent problem of granular synthesis of sculpting a huge amount of grains without specifying the parameters individually. The visual domain has its particular idiosyncratic organization, which guides the user in an intuitive process of arranging the sound material.

We also found the *GranScore* very useful for educational purposes, its intuitive interface allows the user to learn about granular synthesis in a short period of time. So, in the near future, we would like to establish a partnership with students of an electroacoustic music class in order to explore and measure the didactic possibilities of the *GranScore* as a tool to teach granular synthesis.

As software developments we intend to improve the *GranScore* implementing some musical features like, for instance, defining a kind of "serial" operators such as inverse, retrograde and inverse-retrograde for any subsets of grains in a composition, "loop like" playing continuously selected grains, real-time score for live performances and the splitting sets of grains in distinct streams with different geometrical shapes.

In a more general aspect we have conceived also a theoretical framework for a general graphic interface we called RISO (Reading Interface for Sound Object). RISO can be thought as a dynamical score for several sound objects, including the usual ones (notes, rests, etc.) as they appear in traditional computer score editors. RISO has two types of objects: *reading objects* and *sound objects*. Sound objects, which visually can have several geometric forms, are placed in a window (Sound Objects Space –SOS), which can be interpreted as a *graphic score*, and are static (no motion) and are, initially, in the ground state (silence). Reading objects, or simply, readers, are dynamical (moving) objects, which read (intercept) the sound objects. In this case the "interaction" between the two objects excite the sound objects to another state (excited state) and a sound is sent to the output.

RISO, in principle, is intended to be very flexible to play different sound objects or sound files with multiple reader objects. This means the reader, or even many readers at same time, makes its trajectory through all SOS and doing this they excite a number of sound objects generating an output sound file which can be played in sequel, pretty the same as software traditional scores. So, it is our next goal that all the achievements we have realized in GranScore could be generalised to RISO project.

5. Acknowledgments

F. Falci thanks FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) for a Dr. Sc. Scholarship. A. Maia also acknowledges CNPq for a research fellowship.

References

GABOR, D., *Theory of Communication*, JIEE, Vol.93, Part 3, No.26. London, pp.429-457 (1946).

GABOR, D., *Acoustical Quanta and the Theory of Hearing*, Nature **159** (4044), pp. 591-594, (1947).

LIGETI, G. (WEHINGER, R.). See <https://www.youtube.com/watch?v=71hNl_skTZQ>. Acessed in March, 23, 2013. *Artikulation*. Dur: 3m53s.

MAIA Jr. A., Miranda, E.R., *Granular Synthesis of Sounds Through Markov Chains with Fuzzy Control*, Proceedngs of The International Computer Music Conference (ICMC), 2005, Barcelona, Espanha.

MARINO, G., Serra, M., Raczinski, J., The UPIC System: Origins and Innovations, Perspectives of New Music, Vol 31, N º 1, 1993, pp. 258-269.

ROADS, C., *Introduction to Granular Synthesis*, Comp. Mus. Jour., **12** (2), pp. 11-13 (1988).

ROADS, C., *Microsound*, MIT Press, Cambridge,MA, (2001).

SOUZA, F. F., *Audio-Visual Granular Synthesis*, III Encontro Internacional de Música e Arte Sonora, EIMAS, Juiz de Fora, 2013.

SOUZA, F. F., Wanderley, M. M., Maia Jr., A., *Evolutive Processes for Granular Synthesis in Extended Gabor Spaces*, Anais do 7º Congresso de Engenharia de Audio, São Paulo, Brazil, 2009.

SOUZA, F. F., Wanderley,M. M., Maia Jr., A., *An Input Device to Granular Sound Processes*, Anais do 8º Congresso de Engenharia de Audio, São Paulo, SP, 2010.

THIEBAUT, J., Healey, P.G.T., Kinns, N.B., *Drawing Electroacoustic Music*, Proceedings of ICMC 2008, Ann Arbor, MI, USA, 2008.

THOMSON, P., *Atoms and errors: towards a history and aesthetics of microsound*, Organized Sound, **9** (2), pp. 207-218, (2004).

TRUAX, B., *Real-time Granular Synthesis with Digital Signal Processing Computer,* Computer Music Journal **12** (2), 14-16, (1988).

TRUAX, B., *Composing with Real-Time Granular Sound*, Perspectives of New Music, Vol.28, No.2. 1990.

VALLE, A.; Lombardo, V., *A two-level method to control granular synthesis*, Proceedings of the XIV Colloquium on Musical Informatics, Firenze, 2003.

XENAKIS, I., *Formalized Music: Thought and Mathematics in Composition*, Hillsdale: Pendragon Press, 2001.