Harnessing the Enactive Knowledge of Musicians to Allow the Real-Time Performance of Correlated Music and Computer Graphics

Ilias Bergstrom and R. Beau Lotto, University College London, Institute of Ophthalmology, 11-43 Bath Street, London, EC1V 9EL, United Kingdom. E-mail: <i.bergstrom@ucl.ac.uk>.

Keywords

Real-time performance, enactive interfaces, visual music, new media, digital musical instruments, mapping, colour organs, programming as art.

Artists and scientists have a perpetual interest in the relationship between music and art. As technology has progressed, so too have the tools that allow the practical exploration of this relationship. Today, artists in many disparate fields occupy themselves with producing animated visual art that is correlated with music (called 'visual music'). Despite this interest and advancing technology, there still is no tool that will allow one to perform visual music in *real-time* with a *significant level of control*. Here we propose a system that would enable a group or individual to perform live 'visual music' using the musical instrument(s) itself as the primary source of control information for the graphics. The hypothesis driving this choice of interface is that, by connecting musical control data (i.e. scales, notes, chords, tempo, force, sound timbre and volume) to graphical control information (a process called *mapping* [6]), a performer will be able to more readily transfer his/her enactive knowledge [1] of the instrument to creating visual music. The term enactive knowledge refers to knowledge that can only be acquired and manifested through action. Examples of human activities that heavily rely on enactive knowledge include dance, painting, sports, and performing music. If our hypothesis is correct, this will enable a mode of musical/visual performance different from current practice, which is likely to enhance the experience of both the performer(s) and audiences.

The outcome of this process will not simply be music visualization, with the graphics being subordinate. Rather, we believe that images controlled directly by the same physical action that generates music will feedback to shape what is actually played musically by the performer. Furthermore, many people will be able to collaboratively perform a complex musical and visual experience live – in a manner that live musicians are already used to, because each performer will be influenced by the performance of the others in the group.

Background

The immediacy with which music can communicate emotion has been envied by many visual artists, most notably Wassily Kandinsky [2], who set out to recreate it in painting. The first known machine for exploring the relationship between music and visual art, was Louis-Bertrand Castel's "Clavecin oculaire" (1734), who implemented a modified version of the note to color correspondence proposed by Isaac Newton [2]. Many such systems have since followed, made to either accompany music with colour, or provide a form of visual music - named "Lumia". The term Lumia was coined by Thomas Wilfred, developer of the "Clavilux" color-organ (1922) [2], who, rejecting the notion of an absolute correspondence between sound and image, concentrated on generating visual compositions that were meant to be viewed alone, i.e., without musical accompaniment.

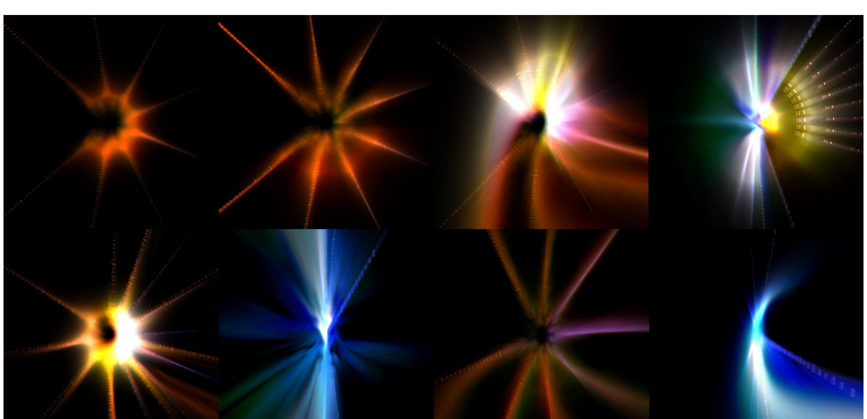
Though lacking an entirely rigid definition, what qualifies as Visual Music is sufficiently well described by Brian Evans [3] as: '*time-based visual imagery that establishes a temporal architecture in a way similar to absolute music. It is typically non-narrative and non-representational (although it need not be either). Visual Music can be accompanied by sound but can also be silent*'.

In modern times, analogue video synthesizers, laser shows and more recently computer graphics have all been employed to accompany music. For instance, at live music concerts and at clubs with music played by a DJ, there are often live graphics performed by a VJ (for Visual Jockey), who mixes pre-recorded video clips together, while altering the playback parameters of the individual clips, as well as processing these clips using real-time video effects. A further advance has been the recent development of computer programming environments, such as Processing [4] and Cycling74's Max/MSP/Jitter combination, that allow the description and performance of real-time procedural graphics by non-expert programmers, and as such their use has begun making its way out of the avant-garde and into VJ sets and other 'new media art' performances. Despite the intense interest in visual music, and advances in its associated technologies, current tools/practices are limited in three ways: (i) highly constrained, linear mappings, (ii) limited controllability, and (iii) overly complicated process for preparing new performances.

Existing limitations

In current practice the mapping between sound and graphics is typically reduced to the beat and amplitude of the music. What is more, such mappings quickly become highly predictable, thus restricting the use of suspended expectations [5], as well as tension and release [3], which are crucial aspects of artistic/esthetic narratives. It is known that the human perceptual system is apt at detecting correlated stimuli across modalities, and fusing these into a single percept before their interpretation [8]. More detailed correlation may thus further encourage the unified experience of music and image. Furthermore, visual music performances are controlled using often highly *un*intuitive interfaces on computer screens and/or external hardware controllers (with knobs, sliders and buttons, etc, also referred to as non-musical controllers). Together these limitations mean that controlling visual music is a far cry from the level of control that musicians have of their instruments.

Fig. 1. Sequence of images produced using prototype. (© Ilias Bergstrom.)



Finally, existing multimedia programming environments prevent a program created by one performer to be easily used by other performers for achieving their individual esthetic goals, making such programs very limited in their usability.

Proposed system

The system proposed here overcomes these three limitations, while simultaneously introducing several novel concepts for the real-time visual music performance using computers. Here we will describe the proposed system and the concepts that it engenders.

The system consists of three modules: one to host the graphics rendering, a second module to gather musical control information from musical gesture controllers [6], and a third to adapt the 'mutable mappings' between the parameter spaces of the control data input, and of the graphics rendering.

Although mixing multiple layers of moving graphics, as in VJing, will be retained, these graphics are not constrained to pre-rendered video clips, but the output of real-time visual synthesizers ('synths') that run in parallel within the main host application. Each visual synthesizer is a program that renders a particular visual effect, the control parameters of which are all accessible online during a performance, so that the appearance of the visual is animated over time. 'Synths' can be created as Processing 'Sketches' [4], using a processing library provided that enables the sketch to work within our host application. Alternatively, synths can come from a collection of sketches provided with the host, or from other users. In this way we facilitate the performance of advanced real-time computer graphics by non-programmers by encapsulating the programming complexity in flexible modules that are easily exchanged and managed.

More importantly, the parameters of the visual synthesizers are not primarily controlled using a screen and/or non-musical controllers more generally. Both visuals and music are instead controlled using the instruments themselves: using, for instance, scales, notes, chords, tempo, force, sound timbre and volume. Additional non-musical controllers, such as banks of sliders, knobs, switches, light sensors, touch-screens, etc, may still be used as further sources of control data. Possible input sources include musical and non-musical data from MIDI or OSC [6], as well as Multi-channel audio.

MIDI technology is a well-established standard for transmitting musical information, while OSC is its recently developed successor. There are few instruments whose output cannot be translated to MIDI/OSC, while many non-musical controllers also produce data in these formats. In addition, any monophonic sound source (e.g. the human voice) can be used to produce musical information using pitch-identification [6]. Using the musical instrument as a user interface will allow a previously unachievable level of control over real-time computer graphics, since the method takes advantage of the enactive knowledge [1] that playing a musical instrument affords.

Of particular importance for the proposed system is that there will be *no hardwired mapping* between the musical control information and the control parameters of the visual synthesizers. Instead the mapping(s) will be mutable: created and modified before and even during a performance, thus enabling performers to construct a non-linear, dynamic and free-form narrative in the correlation between sound and vision, thereby introducing a further means of expression.

Given mutable mappings and the retention of non-musical controllers in the system, an additional role in the performing group, dubbed the 'visual mixing engineer', will be created, who is responsible for designing the system's initial state: (i) the visual synthesizers, (ii) animations to be controlled, (iii) the mutable mappings, as well as gradually altering connections between the streams of control input and control parameters of the visual synthesizers during performance. At any instant, one, a subset, or even all connections may evolve. In this sense, his/her role is analogous to that of the audio mixing engineer, who focuses on the overall (visual) music performance, while the musicians concentrate on their individual parts.

Naturally and finally the proposed system will be useable in all contexts where live music is performed, either using traditional direct manipulation instruments, or conducting gesture controllers [6].

Discussion

Here we have provided a high-level description of a novel system that would allow the live performance of 'visual music' with a level of control significantly greater than is currently possible. In current practice only limited correlations between the aural and visual, and limited real-time control over the graphics drawn are possible. The novel methods introduced here directly address these identified limitations of current practices. The proposed system will allow performers to control real time generated imagery using control information directly derived from the musical instrument(s). We will furthermore enable artists without the skills of computer programming to significantly influence the content of their visual performance, while also keeping the programming of new graphics algorithms accessible to those seeking greater creative freedom.

More generally, our proposed system (and our programme of research more generally) may in the long run help address a shortcoming that computers often have when employed as creative tools: the creative process is rarely in real-time. This is especially true in the field of computer graphics. Recent advances have allowed us to display real-time, interactive graphics of great visual quality, but the process for creating and controlling their animation is still highly time consuming and technical. Recent research clearly shows the advantages of creating user interfaces that acknowledge the understanding of human cognition as being highly embodied in the interaction between humans and computers [1] [7]. This however has not yet been sufficiently explored in practice.

Finally, the conduct of performing by continuously altering the mapping between two parameter spaces is in itself a novel mode of performance, equally applicable to many other contexts.

References

1. Enactive network; <www.enactivenetwork.org>, accessed 7 March 2008.

2. K. Peacock, "Instruments to Perform Color-Music: Two Centuries of Technological Experimentation," *Leonardo*, vol. 21, 1988.

3. B. Evans, "Foundations of a Visual Music," *Computer Music Journal*, vol. 29, 2005.

4. C. Reas and B. Fry, *Processing: A Programming Handbook for Visual Designers and Artists*, MIT Press, 2007.

5. N. Steinbeis, S. Koelsch, and J.A. Sloboda, "The Role of Harmonic Expectancy Violations in Musical Emotions: Evidence from Subjective, Physiological, and Neural Responses," *Journal of Cognitive Neuroscience*, vol. 18, 2006.

6. E.R. Miranda and M.M. Wanderley, *New Digital Musical Instruments: Control And Interaction Beyond the Keyboard*, AR Editions, 2006.

7. P. Dourish, "Where the Action Is: The Foundations of Embodied Interaction", MIT Press, 2001.

8. P. Larsson, "Virtually Hearing, Seeing, and Being: Room Acoustics, Presence, and Audiovisual Environments," *Doctoral Thesis,* 2005.