Recursion, Symmetry & Tessellation with Software based Video Feedback Systems

Paul Prudence
50d College Park Close
Lewisham, London
SE13 5HA
E-mail: paul@transphormetic.com

Abstract

Talysis II and Son Lattice are real-time generative software pieces that apply the properties of video signal feedback to simulate recursive functions, typical of a computer algorithm, to build self-similar, symmetrical geometric forms. First shown at 'Art-ficial Emotion 3.0' in São Paulo, 2006, Talysis II evokes the geometric work of 60's Op-art movement. Son Lattice, performed at 'Tomorrow Now' Venice, 2007 is a sound responsive piece that visualizes sound in real time. Both works are relevant to the field of Art-Maths, not only through recursion, but also because they display properties of symmetry, tessellation and harmonics more commonly associated with computer algorithms and the complex equations of dynamical systems.

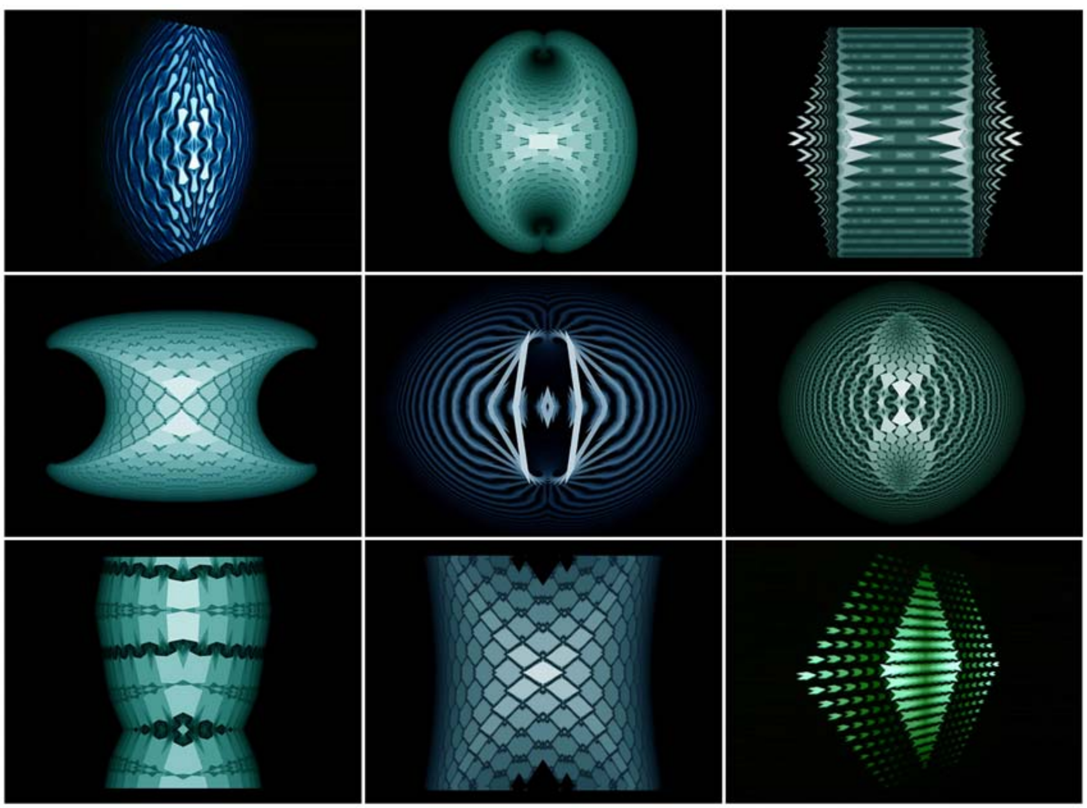

Figure 1: *Screen shots of Talysis II. Shown at Art.ficial Emotion 3.0, Sao Paulo, July 2006*

1. Introduction

Talysis II (figure 1), a real time generative [1] artwork, was commissioned for the Art.ficial Emotion 3.0 exhibition held in Sao Paulo in July 2006. This was an exhibition surveying historical and contemporary cybernetic [2] and interactive digital art. The artwork, built using the video synthesis toolkit VVVV [3], simulates the process of analogue video feedback by constructing a loop of renderer nodes. Each node passes its output to the next renderer node to produce an endless visual information loop with degrees of transformation throughout the process. The initial starting source shape is a simple white square or Quad (in VVVV terms). The final result is a set of symmetrical geometric patterns displaying nesting, recursion and complex tessellation as the Quad is transformed a little in shape, position, orientation and hue during its conveyance around the loop.

One of the key attributes of generative art is in its use of repetition of elements arranged in patterns or multi-form elements spread in space to produce a decorative arrangement. Common textual programming principles that allow the generation of multiple objects in 2d or 3d space are conditional loops (iteration) and recursive functions. Talysis II uses video feedback (output as input) to simulate a recursive function to produce self-similar patterns to this end. Recursive functions are special kinds of functions that use the output of a process or computation as its input, these functions define many of the self-similar forms found in nature, and fern leaves are a good example.

2. Analogue video feedback (Talysis I)

Standard analogue video feedback is the process of using the output of a video camera as its input. The set up and process is very simple even though the results are very complex. A camera is connected to the monitor and pointed at that monitor so that the results can be viewed in real time. By changing the camera settings, brightness, contrast, using the zoom and by moving the camera, very complex vortexes, tessellated arrangement of shapes, aggregations and emergent patterns begin to arise.

In terms of scientific history, information is more scant and this is due to the fact that video feedback is notoriously hard to control and results difficult reproduce. This alchemical-like notoriety is one of its key attractions for artists. One scientific paper, by James Critchfield, ‘Space-Time Dynamics in video feedback’ [4] stands above all others. Critchfield explores mathematical aspects of video feedback and concludes that it could be used to understand many areas of dynamical system science.

‘Talysis I’ the precursor to ‘Talysis II’ was made for the Crystalpunk Workshop for Soft Architecture [5] held in Utrecht, 2005. The film was commissioned for the purpose of exploring self-organisation and autocatalytic replication in complex systems using the analogue video feedback method described. Using mirroring along the vertical or horizontal axis (or Quad symmetry with both axis) in the feedback loop familiar recursive structures begin to appear, self-similar curves very much like the Koch snowflake, for example (see figure2 middle row, far right). The same image has notable similarity to Escher’s ‘Square Limit’ where repetition is combined with a reduction factor of a half and repetition is confined inside 45° triangles.

At first a glance of the stills from Talysis I (Figure 2) might appear to have been taken from a biology textbook. There are neural networks, synapses, biological tissues, capillaries, plant structures, and embryonic forms. At certain points in the animation, Talysis I begins to behave like a computer program as it organizes and animates units in a similar way to a Cellular Automata program. Since certain Cellular Automata have been proven to be Turing Complete [6], I propose that Video Feedback has the ability to behave as a Universal Computer. This claim has gained some considerable interest [7] by Andrew Ilachinski, author of ‘Cellular Automata – A Discrete Universe’, 2001. Video Feedback can also produce figures with notable similarity to Sierpinksky Gaskets and Turtle/Dragon curves as well as many other well know species of Fractals all without a single line of code as seen in Figure 2.

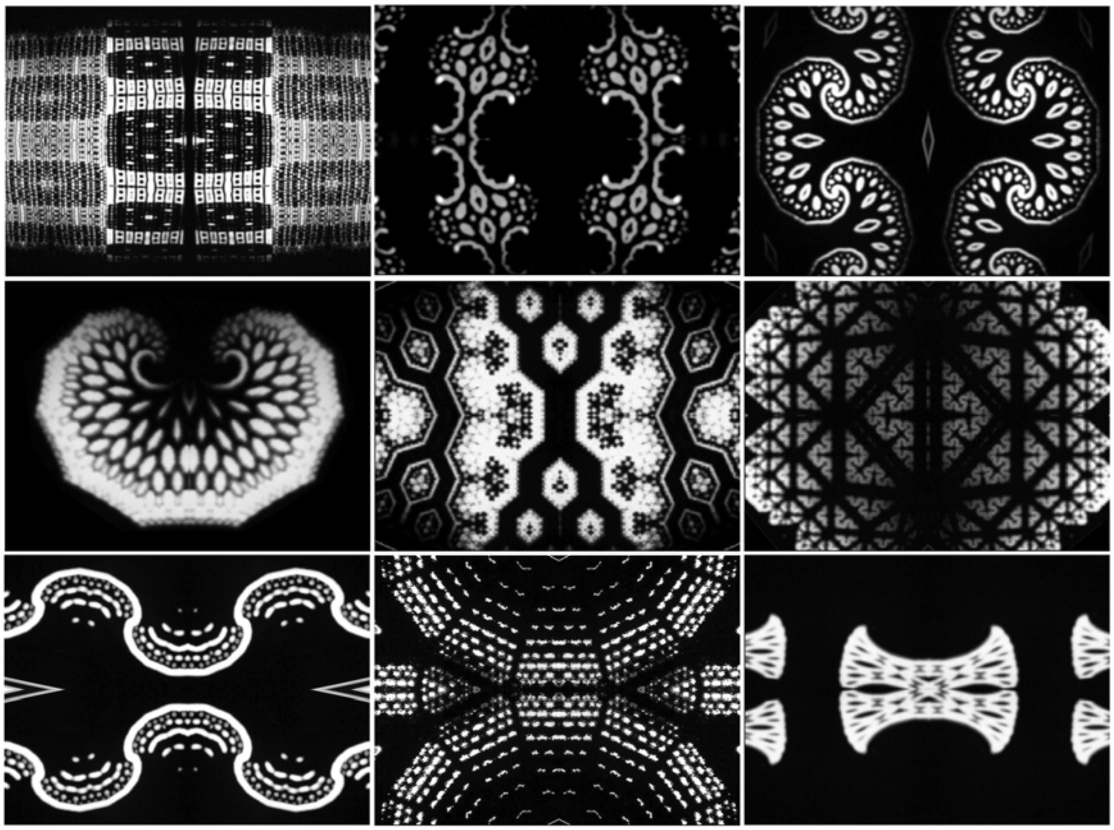

Figure 2: *Screen shots of Talysis 1, 200*5

Taking a lead from Crutchfield's paper we may even begin to suppose these feedback systems could be seen to map the shapes and contours of consciousness itself, more recent work by Douglas Hofstadter[8] continues these investigations – both reads are recommended to the reader.

3. Software simulated video feedback with VVVV (Talysis II & Son Lattice)

As previously mentioned, analogue feedback is very difficult to control and replicate. The technique brings with it associated issues when trying to produce an artwork for an installation set-up. To circumnavigate this problem I set about producing a set of prototypes that allowed me to simulate visual feedback loops with much less degree of unpredictability. This allowed me to develop a coherent aesthetic path resulting in the various species of Talysis II (figure1). Talysis II is built using Meso's toolkit for video synthesis, VVVV, a patch based visual programming language utilizing the openGL/direct X [9] framework. Visual programming differs from textual programs (lines of code) in that you can connect together nodes (objects with inputs and outputs) that have specific functions/purposes to produce complex video synthesis systems.

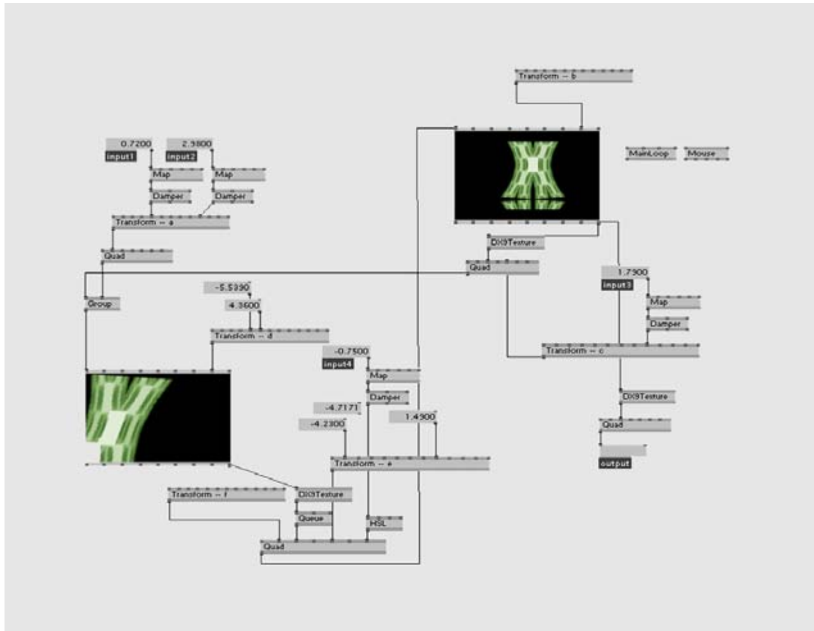

Figure 3: *Talysis I1 patch in VVVV, 200*5

Figure3 shows a simple feedback loop built in VVVV, where one renderer passes its video information to the next, which passes it back to the first. Properties of the video are transformed during the cycle. Symmetrical transformations give more complex results. ‘Transform’ nodes added to the circuit allow the Quad to be transformed during the feedback loop. The Quad can be scaled and positioned in the X, Y and Z-axis. The Pitch, Yaw and Roll the Quad can also be manipulated. If one imagines a Quad (centered initially) being rotated then shifted on its X-axis - when it reaches the second renderer the Quad will be off-centre and at an angle. The second renderer sends this signal back to the first, again with some degree of transformation. Fundamentally we have a transformation of a transformation of a transformation and so on to create complex arrangements of units in space. These transformation properties/parameters can be made to change over time using oscillators to create undulating animations. This creates a smooth metamorphosis between one ‘species’ of Talysis II and another. Random parameters, within predefined limits, can be used to uniquely generate each configuration. By predefined limits, I mean maximum and minimum values that will keep the Quad within the boundaries of the renderer, scaled and transformed according to my specific aesthetic requirements. The fine-tuning is done by changing the input values of the Transform node experimentally in real-time and making notes of the values according to the outcome. A table of ‘special’ value ranges can then be drawn up and random values generated from them. These values can be interpolated to create forms and configurations of special interest.

External ‘sensing’ of the installation space can be used to give interactivity to TalysisII. Infra red cameras are used to track the movement of people in the gallery space. The information is mapped to parameters and passed to Talysis II allowing a second feedback loop to occur between the viewer and the piece. As the viewer moves so Talysis II reacts arising in a rudimentary cybernetic dialogue. Another method in which the piece can access external data is the use of sound analysis. Using frequency and volume analysis, software based video feedback can be used to visualise sound in real-time and to produce wave like animations and interference patterns. Son Lattice (figure 4), made with VVVV, was performed at ‘Tommorow Now – Engage the code’ in Venice, 2007 and uses this technique. FFT [10] (Fast Fourier Transformation) allows different frequencies in the sound to be analysed to drive difference parameters in the feedback loop. Acting as a kind of stylus, the Quad can be made to move in one direction according to the prevalence of high frequencies and change in size or brightness according to the amount of low frequencies. Due to the harmonic attributes of video feedback we can begin to construct visualisations/animations of sound that bear good resemblance to the properties of waves in liquids. Further, these animations have a good relationship to the concept of Cymatics. [11]

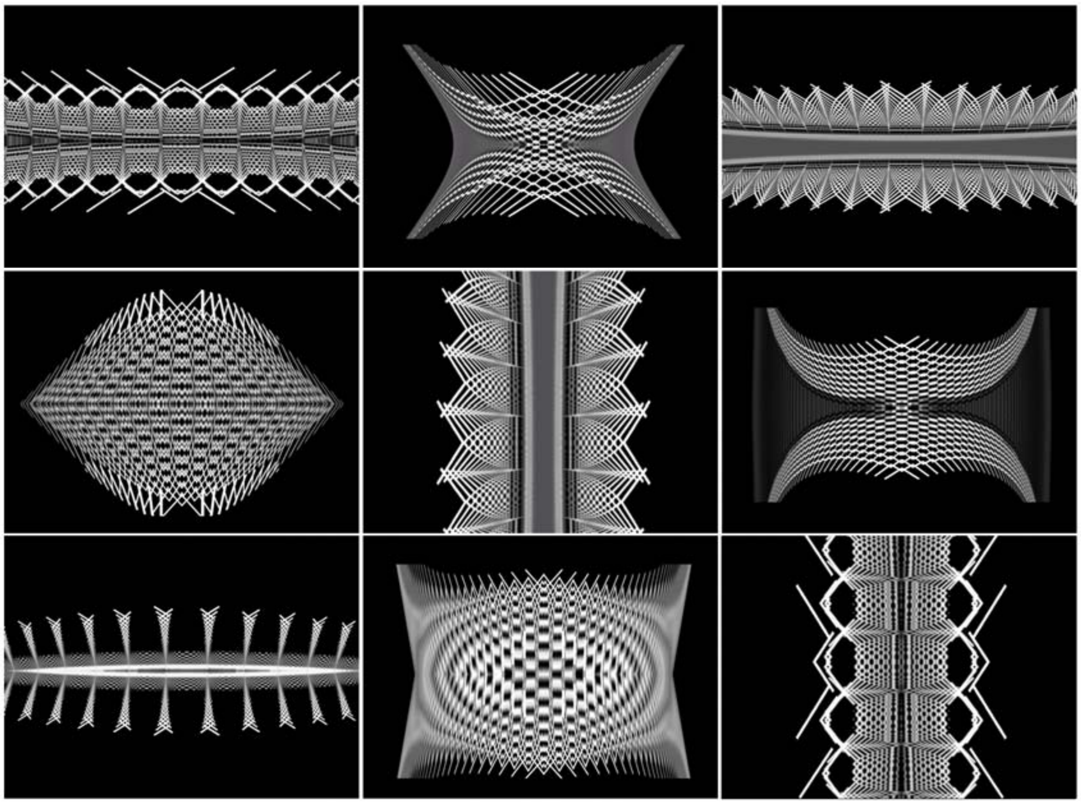

Figure 4: *Son Lattice, Performed at 'Tomorrow Now – Engage the code" Venice, 2007*

4. Conclusion

Video feedback, both analogue and software based, can be used to simulate complex mathematical computations and display properties of emergence. Video feedback systems are excellent test beds from which to study spatial complexity, reaction-diffusion equations, morphogenesis, dynamical systems and recursive tessellation. Video Feedback offers an aesthetic approach to the study of recursive exotica without the requirement of complex math equations. It is a fast and convenient approach to producing complex geometric multi-form digital artworks.

Recursion has existed in art from many cultures even before the word 'Fractal' came into being, 'African Fractals: modern computing and indigenous design' by Ron Eglash [12] explores recursion in African architecture, textiles and art. In the 60s and 70's the graphic artist MC Escher [13] explored complex tessellations with hyperbolic properties like those found in Talysis II. Beyond art, recursion is insinuated in mythology. The myth of the Ouroborous [14], the snake who eats his own tail, could be seen as a model for recursion and self-perpetuating loops.

References

[1] Generative art has been defined as “any art practice where the artist creates a process, such as a set of natural language rules, a computer program, a machine, or other mechanism, which is then set to motion with some degree of autonomy contributing to or resulting in a complete work of art.” What is Generative Art - Philip Galanter, 2003. - http://www.philipgalanter.com/downloads/ga2003_paper.pdf

[2] Cybernetics is the interdisciplinary study of the structure of complex systems especially communication processes, control mechanisms and feedback principles. http://en.wikipedia.org/wiki/Cybernetics

[3] For info and download of VVVV - http://www.vvvv.org

[4] ‘Space-Time Dynamics in Video Feedback’ Physica, 1984 by James Critchfield - http://www.vasulka.org/Kitchen/PDF_Eigenwelt/pdf/191-207.pdf

[5] Info on the Crystalpunk Workshop for Soft Architecture can be found at http://www.socialfiction.org/crystalpunk/index.php

[6] A definition of Turing completeness can be found at http://en.wikipedia.org/wiki/Turing_complete

[7] Ref: http://tao-of-digital-photography.blogspot.com/2006/02/local-fused-wglobal-via-video-feedback.html

[8] I am a Strange Loop - Douglas Hofstadter, 2007

[9] OpenGL (Open Graphics Library) is a standard specification defining a cross-language cross-platform API for writing applications that produce 2D and 3D computer graphics. - http://en.wikipedia.org/wiki/OpenGL

[10] More info on FFT can be found here http://en.wikipedia.org/wiki/FFT

[11] Cymatics is the study of wave phenomena. It is typically associated with the physical patterns produced through the interaction of sound waves in a medium. ‘Kymatics’ Hans Jenny, 1967.

[12] African Fractals: Modern Computing and Indigenous Design - Ron Eglash, 1990

[13] See MC Escher’s ‘Circle Limit I, II & III’ for example.

[14] More info on the Ouroborous can be found http://en.wikipedia.org/wiki/Ouroboros