Packages for ArtWonk: New Mathematical Tools for Composers

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ABSTRACT

This paper describes a series of mathematical functions implemented by the author in the commercial algorithmic software language ArtWonk, written by John Dunn, which are offered with that language as resources for composers. It gives a history of the development of the functions, with an emphasis on how I developed them for use in my compositions.

Keywords

Algorithmic composition, mathematical composition, probability distributions, fractals, additive sequences

1. INTRODUCTION

John Dunn's ArtWonk 4.1, recently released by Algorithmic Arts (http://algoart.com) is a PC-based, reasonably priced, algorithmic composition toolkit which uses a drag and drop patching paradigm for MIDI, computer graphics and text manipulation, is user-extensible, has macro-encapsulation capability to any depth, and has a substantial library of functions for sonification, genetic music research, and microtonality. It is the product of over 25 years of work by Dunn and other composer - programmers, starting with the DOS-based Music Box program in 1984, which was released publicly in 1986, making it one of the first publicly available patching-paradigm algorithmic composition toolkits available. (By comparison, Max did not become publicly available until 1989-90). Over the years, the program has morphed through a number of incarnations, including Kinetic Music Machine in 1992, Kinetic Art Machine in 1996 (still DOS based), Windows-based SoftStep and BankStep in 1998-99, and ArtWonk in 2003. Examples of the changing interface design, from DOS ASCII character graphics for Music Box and the Kinetic Machines, to more user friendly GUI design for SoftStep and ArtWonk are shown below. I began using MusicBox in the late 1980s, and by 1991, had used in in a substantial number of compositions. I got involved with Algorithmic Arts in the early 1990s, suggesting modules, then designing specifications for them, beta testing, etc. With the implementation of User Function modules in SoftStep, it became possible for users to "roll their own" mathematical functions, and this ability became more powerful in ArtWonk, and still more powerful in version 4.1.

Figure 1 : Interface Detail: Music Box and Kinetic Music Machine

Figure 2 : Interface Detail:SoftStep

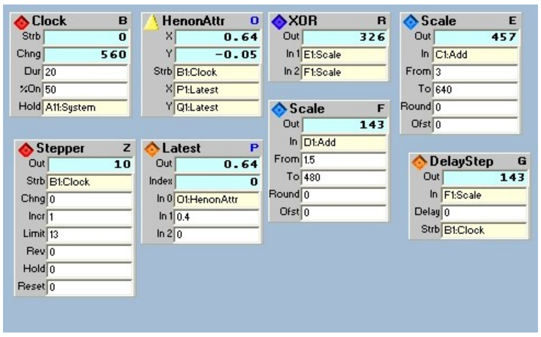

Figure 3 : Interface Detail: ArtWonk

2. ORIGINS

In the early 1980s, Serge Tcherepnin asked me if I had heard of this new thing called "chaos theory," because, he said, the way I was patching analog modules together and the design of some of his modules (such as the Smooth and Stepped Generator) seemed to remind him of this new thing. This piqued my curiosity, and eventually, through my "tame mathematician" friend, the topologist Dr. Henry Hunter, I began learning some of the mathematics involved in the world of chaos, dynamics, cellular automata, fractals, etc. Always one to be interested in new and quirky sources of information, I became involved in applying what I learned to music. I soon realised that the problems of musical mapping were equally as important as the implementation of the mathematics. I wrote several articles about this, including "Some Parentheses Around Algorithmic Composition." (Burt, 1996) I also realised that a mathematical function that "didn't work," but which still produced interesting results, was often a very useful aesthetic object. This stemmed from my continual usage of techniques such as amateur performance, incompetence, found objects, and the like in my composing and performing. As early as 1978, I had been using devices such as pocket calculators in a process oriented manner, deriving information from their limitations, and this has continued up until the present. I've used both mathematically proper and improper functions ever since in my music.

An example of this was the "New Equations" module I implemented in the User Function module in SoftStep in 2000. In this module, 3 equations that I made up, by freely combining the functions available, provided the information which determined pitch, duration, dynamics and timbre choice in the composition "New Equations." (Burt, 2001) These equations existed for no external mathematical purpose and were simply playfully put together by me as a kind of mathematical fantasy to generate (hopefully) unpredictable, but not equally-weighted random, results. For example, one of these functions rotates Input 1 by N bits (up to 31), where N is supplied by Input 2 (modulo 31). The result is then multiplied by the Square Root of Input 1, and the result is then divided Modulo X, where X is supplied by the Modulo input. There is no good mathematical reason to do this, and I doubt the equation would be of any practical use, or that it describes any existing phenomenon. However, it DOES produce interesting patterns. Here are 3 graphs of its output, the first with two counters going into the inputs, the second with two sine wave LFOs in the inputs, and the 3rd with two noise sources in the inputs. All of these are limited with 61 in the modulo input. Notice that in all 3 cases, interesting "grabbings" where one value or another are held for a while, occur. Perhaps over the long term, this function may have a kind of equally weighted distribution, but in the short term, its capable of producing interesting patterns unobtainable any other way. This is but one example of how, for me, all aspects of composition, from the structure to the realisation, are as much toys as they are tools.

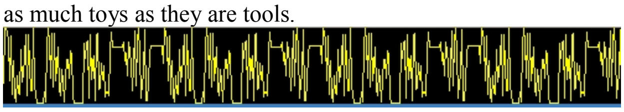

Figure 4: RotSqrt with Counter Inputs

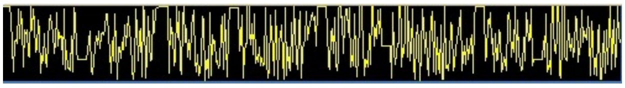

Figure 5: RotSqrt with Sine Inputs

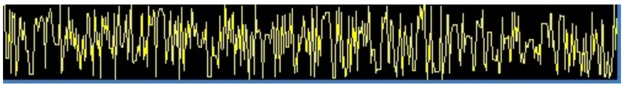

Figure 6 : RotSqrt with Noise Inputs

3. THE MODULES

With the implementation of the Function and Macro modules in ArtWonk, which allowed one to set up simple programs which would interact with the main program, I began implementing a series of "Packages" of functions for ArtWonk which would make a collection of mathematical tools available to composers I began this work in 2005, and in 2009, in preparation for the release of ArtWonk 4.0, updated a number of earlier functions, and implemented many new ones. This paper offers a brief overview of these functions, discusses how they encompass both "working" and "non-working" mathematics, and talks briefly about some uses of them in structuring music. Using ArtWonk's Graphics and Text modules, the equations can also be used to produce computer graphics, and experimental poetry. There are four categories of functions I developed for ArtWonk: Additive Sequence generators, Probability Functions, Fractal Functions, and a special category of Fractal Functions - a family of 3rd order Ordinary Differential Equations described by Julien Sprott in his paper "Simple Chaotic Systems and Circuits." (Sprott 2000) Additionally, I contributed significantly to the development of several of the Fractal modules included in the main body of ArtWonk, especially the Duffing, Henon, Mira and IFS6Dim functions. I made these functions for a number of reasons. First, of course, is so that I would have them to play with, and so that I could share them with others who might also want to play with them. But also, my reason for making and sharing these functions is to show people how easy it is to program new mathematical functions in this language, and to encourage people to make their own functions and to explore this world with me. Enthusiasms are more fun when shared.

The Additive Sequence Generators are the simplest. Each one is simply an implementation on of the additive sequence equations, of which the Fibonacci series equation is the most elementary. In the Fibonacci equation - An = An-2 + An-1, each new number is the sum of the 2 numbers previous to it in the series. Since so many composers have used the Fibonacci series in composing, I thought that it would be amusing to have some of these available as real time information generators. Eleven different equations are realised. They are labeled by a shorthand for their equation. So, for example, the Fibonacci equation is called A21. A because its the first in the series, and 21 because each new element is the sum of the 2nd and 1st previous elements in the series. Similarly, F51 means that its the sixth equation in the series (F in alphabetical order), where each new element is made by adding together the 5th and 1st previous elements in the series. The eleven equations are, in short hand:

A21, B31, C32, D41, E43, F51, G52, H53, I54, J61, K65

The output of each equation is put through a Modulo N divider, and any numbers can be used as the initial "seed" values for the counting. Additionally, there is a reset input on each module which allows one to return to the initial values, or to restart the counting if new values are put into the initial value inputs. The output of the equations are surprisingly musical. The modulo division on the output enables one to have repeating sequences instead of simply counting off to infinity, and some of these sequences can be pretty long, with some nicely coherent patterns within them. I first developed these functions in 2006 for my composition "Proliferating Infinities," as described in my book "Algorithms, Microtonality, Performance" (Burt 2010a), and I've yet to completely explore the wealth of patterns generated by these modules. Another view of the use repeating patterns produced by dividing additive sequencing modulo N can be found in (Armstrong, 2005).

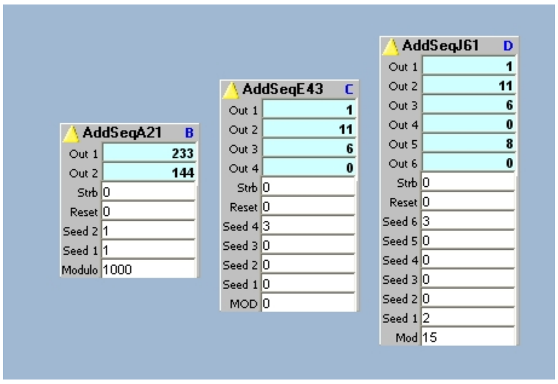

Figure 7 : Additive Sequence Modules in ArtWonk

Probability Modules form the next family of functions. I made these because I was bored with seeing many programs implement the same family of distributions, most of which were described in the Dodge and Jerse "Computer Music" book. (Dodge and Jerse, 1995). I found another source of probability distributions, the "Compendium of Probability Distributions" that came with the Mac-based math program Regress+. (http://www.causascientia.org). Between these two sources, and a couple of others, I assembled a family of 21 different probability distribution modules, each of which allows various parameters to be changed in real time, allowing the distributions to evolve with various kinds of performance control. While most of these distributions are just standard "textbook" realisations, in some cases, such as the Bradford Mistake distribution, I found that a wrong realisation of the Bradford distribution still gave interesting results, so I kept it. A listing of the Probability Functions and Macros follows:

Beta, Borel A, Borel B, Bradford, Bradford Mistake, Burr, Cauchy, Expntl, ExtrmLB, Gauss, General Logistic, Gumbell, LaPlace, Lehmer, Pareto, Reprcl, Weibull, Linear Distributions, Linear Inverse Distributions, Triangle Distributions, Shift Register Feedback.

Each of these could be described at length, along with compositional applications. These are discussed at greater length in the documentation notes for ArtWonk. (Burt, 2010b)

Fractals are the final family of equations offered in my Packages. The Fractal Functions menu contains a number of "working" fractals, but also a number of "broken" equations - which were attempts along the way to getting a "proper" working version of the fractal, but which produced interesting results on their own. Many of these were attempts at realising differential equations in a non-differential, linear manner. The approach was doomed to fail, but along the way, some very nice pattern generators resulted. Each type of fractal "unsuccessfully" implemented in this way, has a working analog in the Fractal Menu of ArtWonk proper, so one can have the choice of legitimate or quirky realisation of a particular fractal.

The fractal functions which are mathematically proper are Icon Sprott (based on Julien Sprott's Icon256.exe program), Fuzzy Duffing (a Duffing attractor with noise added), Ikeda, Latoocarfian and Latoocarfian2, Rossler, Logistic Attractor (the Feigenbaum attractor), Sine Attractor, tENT aTTRACTOR (with a reversed typeface in honor of the US-based multi-artist tENTATIVELY, a cONVENIENCE), and VanderPohl. Functions which are "improper" but still fun are PseudoMira, QuadrupTwo and QuadrupTwoB, Quasi-Sprott 1, 2, and 3, and ThreePly. The appearance of many of the standard fractals is well known from the mathematical literature. But the appearance of these "improper" fractals is not well known, and three of them are included here. Since I value idiosyncracy and uniqueness in music, it only follows that I would value them in the structures used to produce the music, as well.

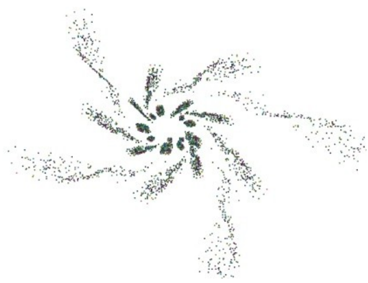

Figure 8 : QuasiSprott Two Output

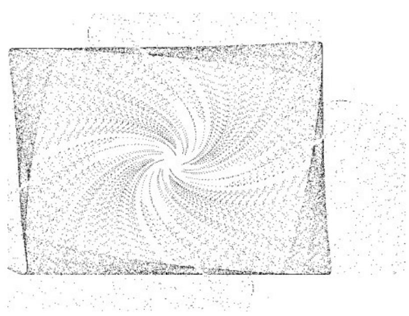

Figure 9 : PseudoMira Output

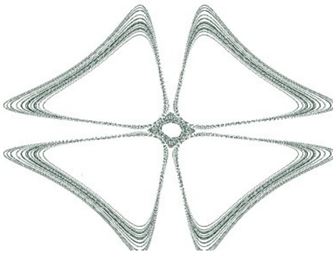

Figure 10 : Quadrup Two Output

Within the Fractal Menu of ArtWonk proper, the following Fractals are contained: Algoart (a unique fractal made by John Dunn), Duffing, Henon, Hopalong, Lorenz, Martin, Mira, Pickover, various Cellular Automata, including a 2D version of Conway's Life, Hilbert, and a 6 Dimensional Iterated Function System.

The final family of Fractals is a set of 13 3rd order Ordinary Differential Equations from Julien Sprott's paper "Simple Chaotic Systems and Circuits" (Sprott 2000). These are the same equations being used in analog circuitry by David Dunn and James Crutchfield in their Theatre of Pattern Formation (Dunn and Crutchfield 2007). These were realised with the help of Mark Havryliv. As I say in the distribution notes for these modules: "When I started this project, I knew from nothing about differential equations, or Runge-Kutta or any of this. Thanks to the generous help of Mark Havryliv, the implementation of the Runge-Kutta algorithm, and the application of these equations to it, has been possible." These equations each generate fairly complex unique output. So far, I've only used one of them in one short piece, "Sprott Attractor Blues," which forms one section of my piece "Algorithmic Demos" which is available for free download on my website, www.warrenburt.com. (Burt 2009) In this short piece, all the blues-like rhythms and riffs were actual unfiltered and unprocessed outputs of the equation. I eagerly look forward to further artistic exploration of these equations by myself and others.

4. CONCLUSION

I made these modules first for myself - I wanted to explore these mathematical worlds, and wanted a LOT of worlds to explore. But I also wanted to share them with others, and also to show others how (relatively) easy it was to make mathematical information sources in this environment. It is my hope that other people will find ArtWonk an attractive environment to work in, and that my resources will become a source of pleasure for many.

5. ACKNOWLEDGMENTS

Thanks to John Dunn, Algorithmic Arts, for his long and friendly collaboration which resulted in making these resources available to composers. Thanks to David Dunn of the Art-Science Lab for sending me the Sprott Chaotic Circuits paper. Thanks to Mark Havryliv for assistance in solving the problem of how to realise the Sprott Equations. Further thanks to David Burraston for mathematical advice along the way, to Ralph Abraham for early advice in using chaos, to Dr. William C. Schieve for discussions about non-linear dynamic systems, and to the late Dr. Henry Hunter, who got me started in exploring these systems.

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