Wind, Sand, and Sea Voyages: An Application of Granular Synthesis and Chaos to Musical Composition

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In this paper I will describe granular synthesis techniques, logistic maps (chaos), genetic algorithms and other methods that I used to compose "The Voyage of the Golah Iota" (1993) and "Colony" (1994).

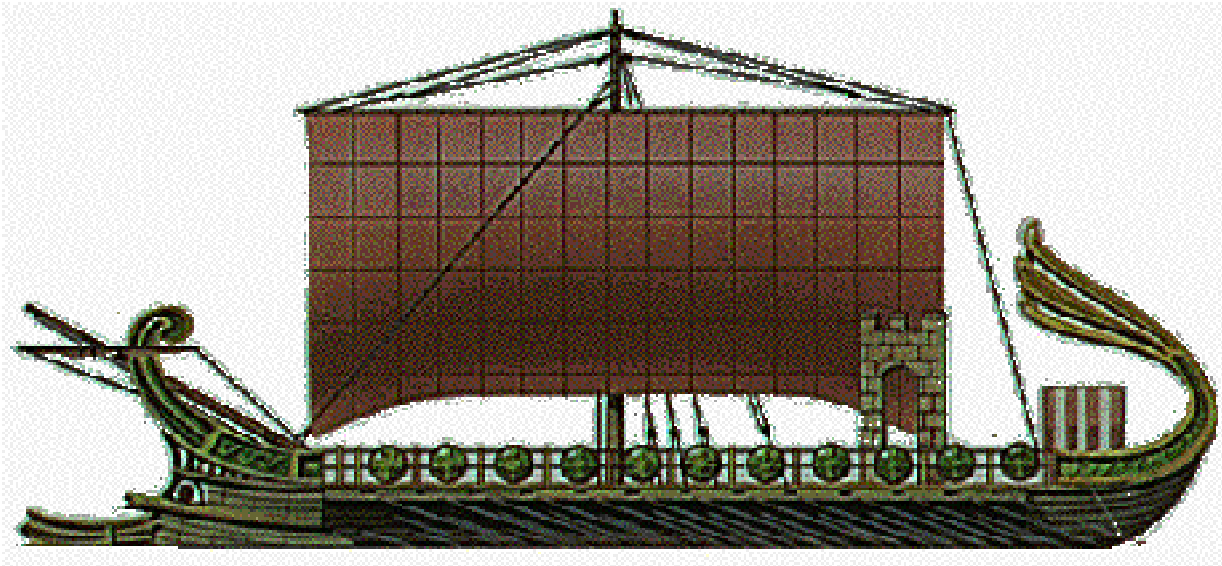
In granular synthesis a large number of small sounds are assembled in masses in a manner that parallels the pointillist painters who created images from small colored dots. The frequencies, amplitudes, timbres, and distribution of the grains cause larger sound structures to emerge.

With "chaos" a simple iterative and recursive function is used to generate musical patterns that vary from single repetitive events to sequences of great complexity with the variation of a single parameter.

This work continues an interest in granular synthesis that dates from 1974 and was revived in 1993 with the composition of "The Voyage of the Golah Iota." In 1974, I was inspired by the writings of Iannis Xenakis and by a conversion I had in Bowling Green, Ohio with one of his students, Bruce Rogers. Bruce played me fragments of works in progress that exhibited sounds unlike anything I had heard before. During the summer of 1974, I composed a series of studies I called "Particulations" using a FORTRAN program of my own design. One of these pieces was included in a concert at the first International Conference on Computer Music at Michigan State University.

The Voyage of the Golah Iota (1993)

When I work on a piece I often construct a metaphor that will guide me through its composition. I use an electronic dictionary, thesaurus, and encyclopedia to sprout the seed of an initial idea. In this case, I began with the words "grain" and "particle." The thesaurus led me to "iota" and the dictionary told me it was a noun meaning "a very small amount, a bit." The dictionary also reminded me that "iota" is "the 9th letter of the Greek alphabet" and that it is of Phoenician origin. A search of the encyclopedia under "Phoenicia" brought me to a picture of a galley (*golah* in Phoenician).



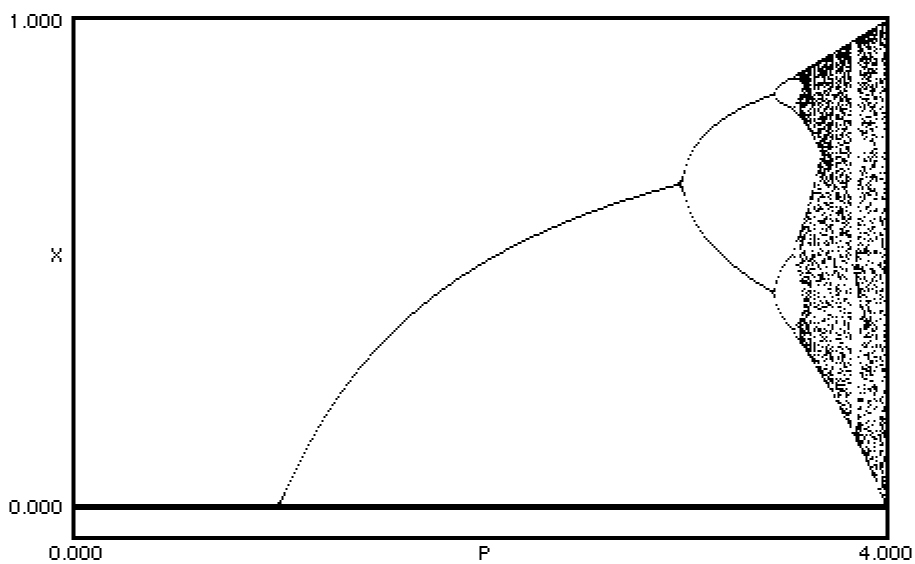
Further reading informed me that there is speculation that the Phoenicians used one of these ships to cross the Atlantic and visit the mouth of the Amazon many centuries before the birth of Christ. If the speculation is correct, the Phoenicians would have predated Columbus' voyage to the New World by more than a thousand years.

My metaphor was now in hand. The shape of my piece would mirror a voyage from the Mediterranean to South America on a mythical ship named the "Golah Iota." This tiny galley would experience, through my sounds, a journey from the calm waters off North Africa through heavy seas and winds to the tranquil shores of what is now Brazil.

The implementation of this model was accomplished with a chaotic function (the logistic difference equation):

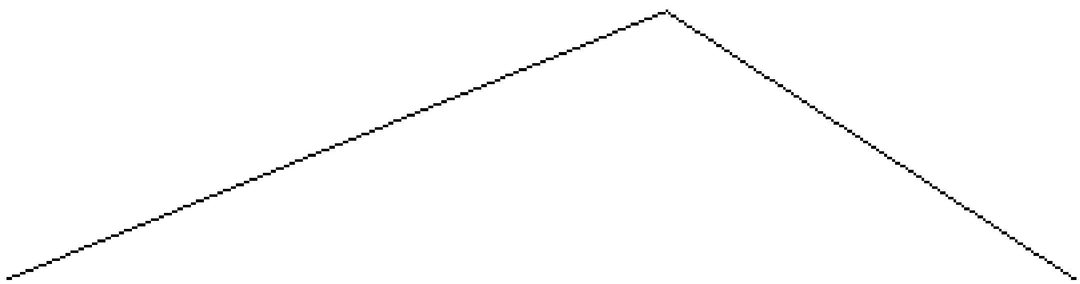
$$X = P*X*(1-X)$$

In this equation, X varies from 0.0 to 1.0 and P varies from 0.0 to 4.0. Here is the graph of the function:



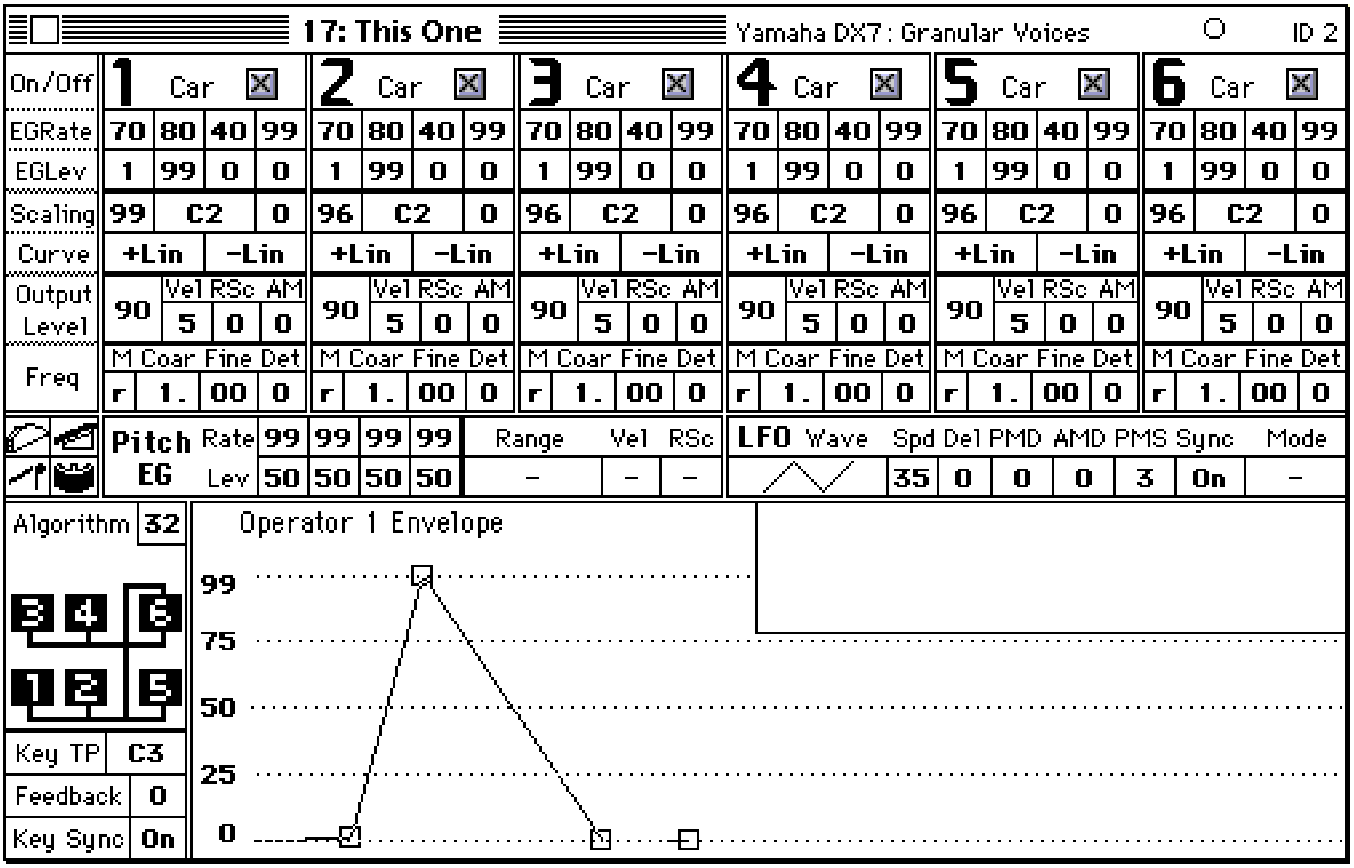
With each iteration of the function, the previous output value for X is fed back to compute the next value. As P increases, the behavior of the function increases in complexity. When P is between 0.0 and 1.0, the functions "dies" (all output gravitates toward zero). Between 1.0 and 3.0, the output values for X converge to a single curve that ascends in value with the value of P. At 3.0 the function bifurcates resulting a in limit cycle of two X values that oscillate. As P continues to increase, the interval between the two values increases until, at 3.5, a second bifurcation takes place to produce a "four cycle." This behavior continues as P increases to about 3.6 where the cycles become so long and complex that they are difficult to follow. This is the chaotic region. In spite of the complexity, every value of P (even to differences in the tenth decimal place) has a characteristic structure that is clearly recognized as an analog to motivic variation.

In "The Voyage of the Golah Iota" and "Colony," I used a function that produced and arch form by interpolating P from 1.0 and 4.0 and back again over the duration of the pieces. "Golah" is eleven minutes long and "Colony" is seven. I used the golden section to determine the proportion between the rising and falling gestures. The rise occupied the longer period.



In "Golah," X values (the grains) were produced with a density of 10 per second when P was at 1.0 and 1000 per second when P reached 4.0. The values of X where scaled and mapped onto a seven octave, micro tonal pitch range (approximately 192 tones per octave). Sound was synthesized in 16 MIDI channels with two Yamaha TX816 synthesizers overlaid with two Proteus/1 modules. The texture was then "smeared" with an Alesis MIDIVERB II. The controlling program was implemented with MAX.

The TX816 timbres for "Golah" were created with Opcode's Galaxy editor/librarian program. First, I made the following two voices:


17: This One
Yamaha DX7 : Granular Voices
ID 2
On/Off
EGRate
EGLev
Scaling
Curve
Output Level
Freq
1 Car
2 Car
3 Car
4 Car
5 Car
6 Car
70 80 40 99
1 99 0 0
99 C2 0
96 C2 0
+Lin -Lin
90
Vel RSc AM
5 0 0
M Coar Fine Det
r 1. 00 0
Pitch EG
Rate 99 99 99 99
Lev 50 50 50 50
Range Vel RSc
LFO Wave Spd Del PMD AMD PMS Sync Mode
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Algorithm 32
Key TP C3
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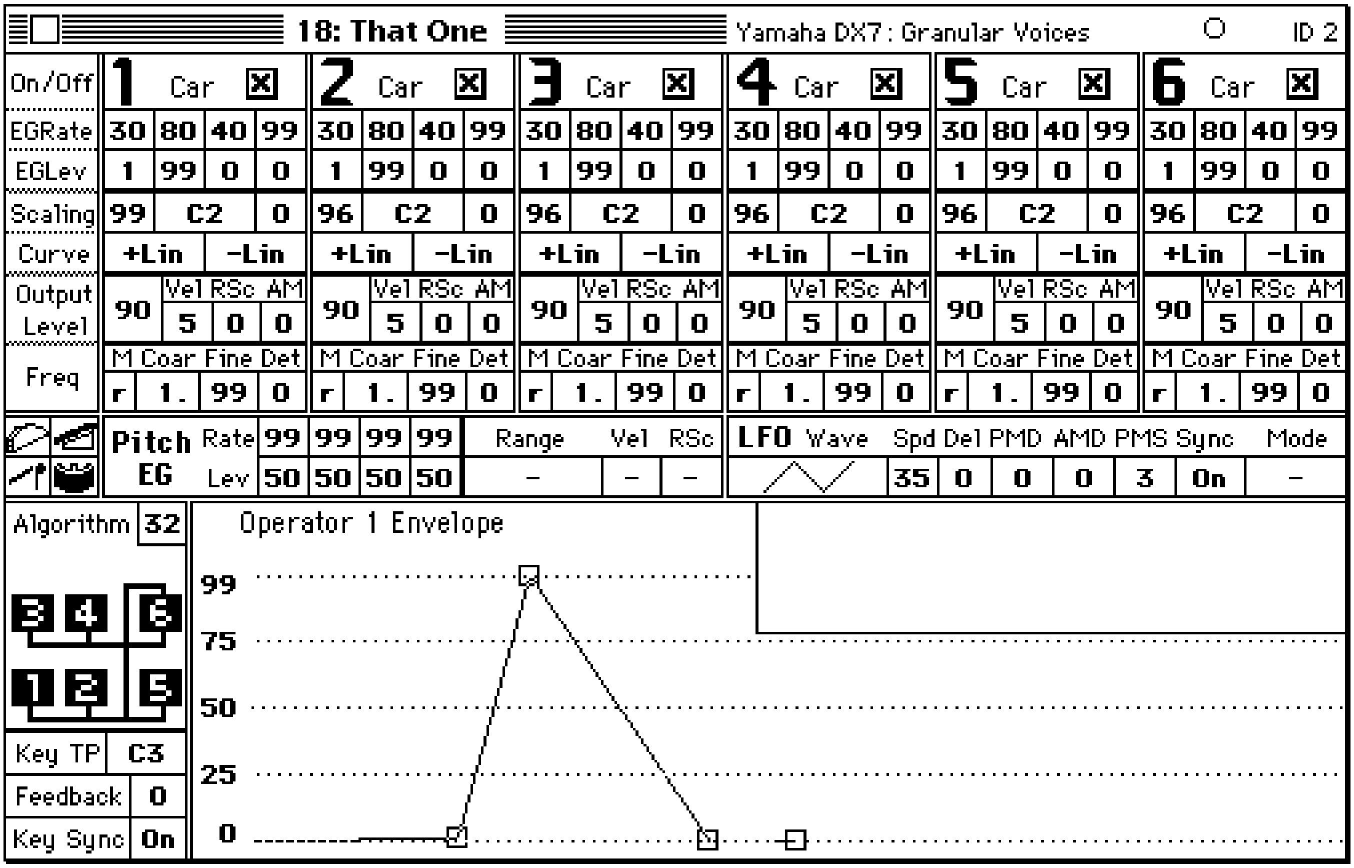
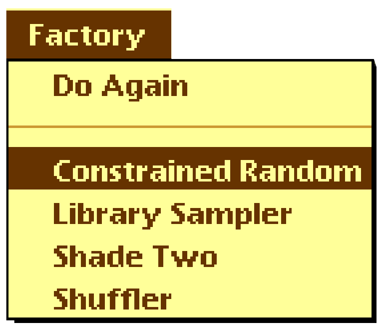
99
75
50
25
0



These voices use algorithm 32 to produce six sine wave signals in parallel each time a note is sent to the TX816. These voices are identical except for the values of "EGRate 1" and "Freq Fine" in each of the six operators. Selecting these two voices from the voice bank prepares for process of controlled randomizing of all of the parameters.

With two voices selected we pull down Galaxy's "Factory" menu and see the following options:

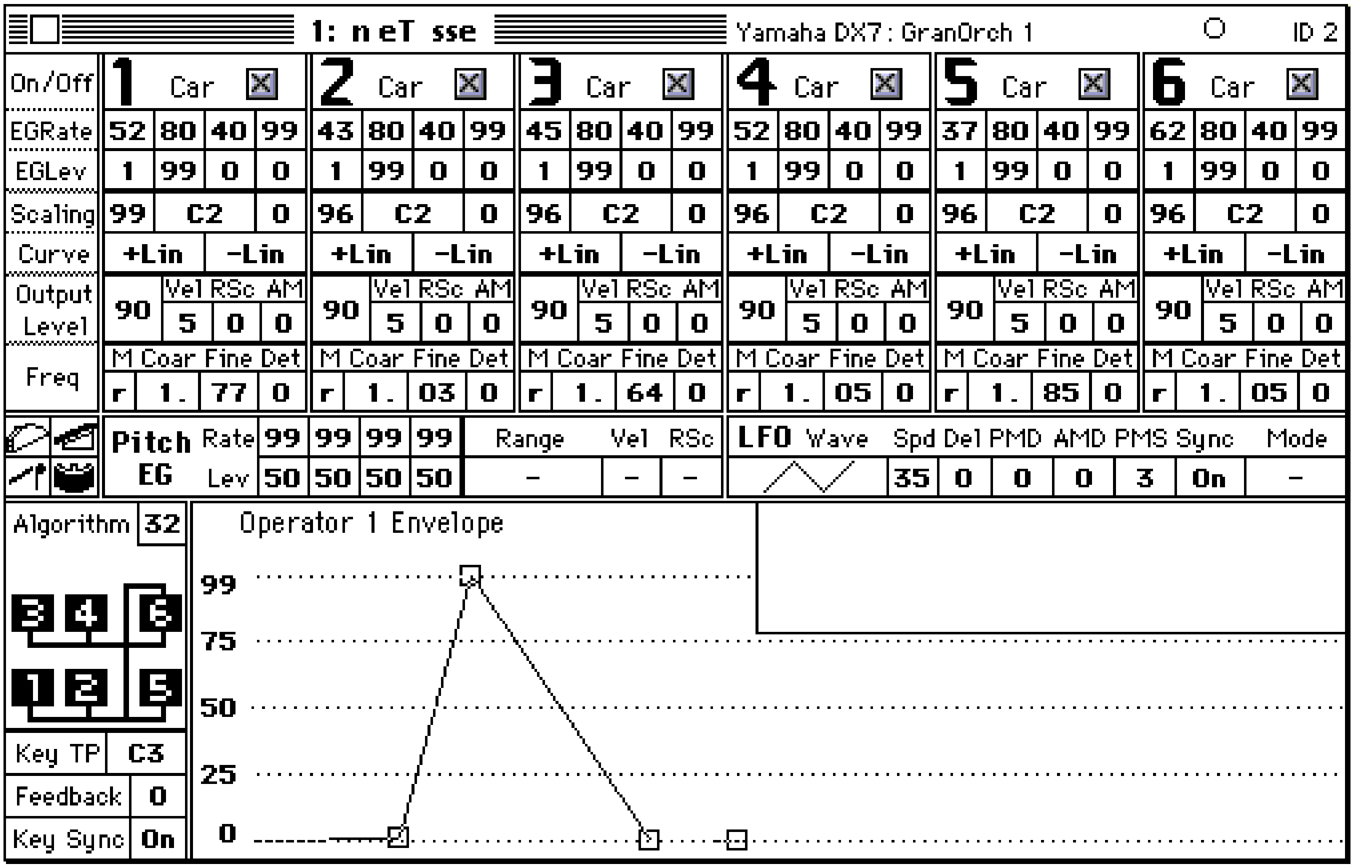


Selecting "Constrained Random" brings up this dialog:

Pressing "OK" with "Create bank" selected produces a new bank of randomized voices:

The new voices share fixed characteristics of their "parent" voices. The differences in "EGRate 1" constrain a random initial envelope delay between 30 and 70 time units. The differences in "Freq Fine" contrain pitch ratios between 1.00 and 1.99 (almost and octave). When a voice is selected with a MIDI program change and a note is sent, the TX816 plays a six note "tune" whose melody and rhythm are determined by random delays and frequency ratios.

If we look at one of the voices in this bank we see initial delays of 52, 43, 45, 52, 37, and 62. Frequency ratios are 1.77, 1.03, 1.64, 1.05, 1.85, and 1.05.



Each module of the TX816's holds one of these generated banks. There are a total of 512 different voices. As the piece is played, program numbers are varied to acheive a constantly changing texture.

Colony (1994)

In "Colony," granular density is very much reduced because of the synthesizers used in its realization. The "orchestra" here consists of two Emu Proteus/1 modules and a single Proteus/2. The texture ranges from a density of 8 grains at the beginning and end to 48 grains at the peak. This lower density and the generally longer duration of the grains may obviate the use of the term "granular." Since artistic ideas have a pleasant tendency to evolve, I'll leave the quibbling over precise terminology to the purists.

The title "Colony" is suggested by another method I used to generate pitch patterns. In working on a book about algorithmic composition I have been investigating "genetic algorithms" (GA). In a GA, the usual method is to begin with a population that is generated randomly.

The initial population is then subjected to rules of evolution that include selection of "parents" based on prescribed characteristics of suitability and breeding of "children" for each subsequent generation. Children inherit genetic features from their parents and, with small possibilities for mutation, future populations evolve. At this point I will remind the reader of the logistic difference equation that I presented earlier:

$$X = P*X*(1-X)$$

Another popular name for this equation is the "Verhulst equation" after the mathematician who invented it to study the ebb and flow of populations under conditions of health and disease, feast and famine.

In a computer nothing is ever random. If we define our terms precisely we must say "psuedo-random." The process of random number generation on a computer is deterministic. What seem like strings of random numbers are actually small portions of a large cycle of numbers that will repeat after millions of iterations. Each new number is made by applying a mathematical function to the previous number in the sequence. A random seed simply specifies where to begin on the circle. If we use the same seed, we will get exactly the same "random" results. Changing the seed changes the sequence and thus gives the impression of a different instance of randomness. The two versions performed on November 9, 1994 differ because of the "seed" that is used to start the random selection of the first generation for the GA. "Colony 110984" and "Colony 110994" use seeds that encode the month, day, and year into a single integer. The first version relates to the founding date of the Society for Electro-Acoustic Music in the United States (SEAMUS) and the second relates to the date of the premiere performance.