

# Philip Glass' *Façades* — a Case Study on the Complexity of Music Scores

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**Abstract.** Assimilating similar music bars with the axial-diagonal self-affine cartoons as defined by Mandelbrot [4], [5] to construct very general multi-fractals, we use one page of a score of Philip Glass' *Glassworks* to define the transition matrix of an order 1 Markov chain to simulate surrogates of the same piece, to investigate whether in this minimalist setting we obtain (i) an exact reproduction of the original, or (ii) something that though different sounds pleasantly.

**Keywords:** superposition of fractals, multifractals, complexity, self-affine cartoons and self-affine bars.

## 1 Introduction

Schröder[9], p. 109, boldly presents the key ideas of Birkhoff's *theory of aesthetic value*: an aesthetic creation is pleasing and interesting when it is neither too regular and predictable like a boring brown noise with a frequency dependence  $f^{-2}$ , nor a pack of too many surprises like an unpredictable white noise with a frequency dependence  $f^{-0}$ .

Multifractal measures — for an early overview of the field cf. Evertsz and Mandelbrot [2] — is a candidate tool to analyze the complexity of musical scores, since a single similarity exponent characterizing a monofractal set is hardly appropriate to render the rich complexity of even minimalist compositions.

Philip Glass' *Façades*, whose interpertrations range from strings, piano, flute/saxophone and oboe to piano and flute (or even an initial 42s section fingerpicked in guitar) is used as a case study on the appropriateness of multifractal tools in the description of musical complexity.

This is a first essay on using such tools, and we shall limit ourselves to assimilate the musical notion of bar (or measure) with the “cartoons” used by Mandelbrot [5], namely chapter N1, or chapter E6 in [4], analyzing bars 19–39 (page 14 of the score of *Glassworks*).

The idea of achieving aesthetic value blending harmoniously repetition with innovation and contrast — in Platzer [8] definition of the classical

rondo, for instance, a principal theme (sometimes called the “refrain”) alternates with one or more contrasting themes, generally called “episodes,” but also occasionally referred to as “digressions” or “couplets” — will be further discussed on an appendix of the full version of this note, where Platzner’s specialist description of the rondo is contrasted to the “amateur” — but nevertheless more eloquent — description in Sorti and Monaldi’s *Imprimatur*. Proust’s lyrical description of the “*petite phrase de Vinteuil*”, and Poe’s *The Philosophy of Composition* where he expresses the essential role of the refrain (limited to the word “nevermore” in his masterpiece *The Raven*, that nevertheless has some dose of consonance with the name of the dead Leonore, and whose component *never* is phonetically the reversion of “raven”

## 2 Façades

Although *Façades* first appeared on Philip Glass’ album *Glassworks*, it was conceived as part of the soundtrack to Godfrey Reggio’s *Koyaanisqatsi*, see [http://www.youtube.com/watch?v=vz\\_R2y1oAzw&feature=related](http://www.youtube.com/watch?v=vz_R2y1oAzw&feature=related) or <http://www.youtube.com/watch?v=GQsoMIGuPD8> for the stream introducing a similar musical theme. Originally scored for an orchestral string section and two saxophones, it is often performed using two flutes instead of saxophones, or scored for 2 soprano sax, viola, cello; synthesizer doubles va/vc. In fact, as Patrick Gary observed in *MusicWeb International*, “Philip Glass is a composer whose body of work readily lends itself to re-orchestration. In fact, many of his early works were written with intentionally vague orchestrations to allow for greater ease in performance.”

Some comments by Philip Glass himself:

“Although I quite liked the way it turned out, it was not used for the film and ended up on my 1982 album for CBS, *Glassworks*. It also has become a staple of the live performances of the Philip Glass Ensemble and was included in *Glasspieces*, the production put on at the New York City Ballet in the spring of 1990, choreographed by Jerome Robbins.” — more precisely, it is Part 5 of *Glassworks*, for more information cf. the appendix on *The IBM Glass Engine*.

“GLASSWORKS was intended to introduce my music to a more general audience than had been familiar with it up to then.”

“I’m very pleased with it, the way it’s received in performance. The pieces seem to have an emotional quality that everyone responds to, and they work very well as performance pieces.”

On the appraisal published in *Gramophone Magazine*, the reviewer wrote “the Glass works gathered together on *Glassworks* make an excellent introduction to the sharp, hard sonorities, densely packed, slowly changing patterns and seemingly unstoppable linear flow of this important aspect of contemporary music.” — we cannot adhere to the expression “*linear flow*”, that certainly is written to convey the more general idea of smoothness.

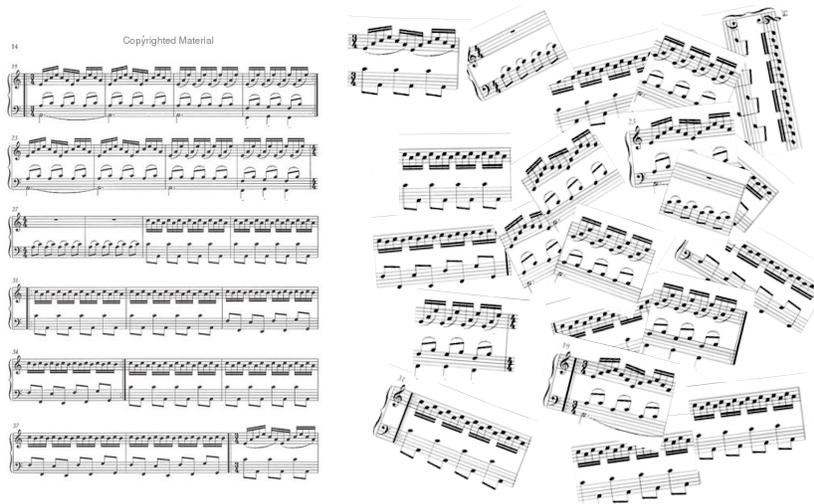
Musical scores are available from [www.ChesterNovello.com](http://www.ChesterNovello.com), that stores interesting information on Glass achievements and works at [http://www.chesternovello.com/default.aspx?TabId=2431&State\\_2905=2&composerId\\_2905=540](http://www.chesternovello.com/default.aspx?TabId=2431&State_2905=2&composerId_2905=540).

### 3 Self-Affine Cartoons, Self-Affine Bars

One of the pathways described by Mandelbrot [4], [5] is via diagonal-axial self-affine cartoons, cf. for instance figures N1-6 and N1-7, pp. 33–34 in [4]. This inspired us to assimilate the idea of self-affine cartoons and of self-affine bars (measures).

Observe however that in any practical human made artifact, or in other practical applications, an important difference does exist: while in the construction of multifractals infinite iteration is conceived, in practical applications a rather limited number of iterations is mandatory, and hence some stopping rule has to be defined, see Pestana and Aleixo [6] and Aleixo *et al.* [1] on stuttering Cantor sets.

For instance, looking at bars 19–39 from page 14 of the score of *Glassworks*, reproduced in the left and “exploded” in the right of Fig. 3 below



**Fig. 1.** Page 14 of the score of *Glassworks*, and an “exploded” view of the 21 bars # 19–39.

we observe that there exist in it only six types of bars, cf. Fig. 3, types 1 and 2, and 4 and 5 being obviously very similar.



**Fig. 2.** Bar types in the 21 bars 19-39 in page 14 of the score of *Glassworks*.

The description of this piece of the score can obviously be rendered very simply as the sequence of bar types  $\{1-1-1-2-1-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6\}$ .

In this preliminary investigation, we decided to assess the probability of recomposing this 21 bars piece using the bar types identified in Fig. 3 together with an order 1 Markov chain defined by the initial state

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

and transition matrix

$$Type\ 1 \mid Type\ 2 \mid Type\ 3 \mid Type\ 4 \mid Type\ 5 \mid Type\ 6$$

$$\begin{array}{l} Type\ 1 \\ Type\ 2 \\ Type\ 3 \\ Type\ 4 \\ Type\ 5 \end{array} \left\| \begin{array}{cccccc} \frac{2}{3} & \frac{1}{3} & 0 & 0 & 0 & 0 \\ \frac{1}{2} & 0 & \frac{1}{2} & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ 0 & 0 & 0 & \frac{2}{3} & \frac{1}{3} & 0 \\ 0 & 0 & 0 & \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \end{array} \right\|$$

(this of course can generate sequences with less than 21 bars, in case a transition from state 5 to state 6 effectively does occur at a discrete time less than 20). The assessment has been made generating 10,000 sequences

- {1-1-1-2-1-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6}
- {1-1-2-2-2-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6}
- {1-1-1-2-1-1-1-2-2-3-4-4-4-4-5-5-4-4-5-5-6}
- {1-1-1-2-1-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6}
- {1-1-1-2-2-1-1-2-3-3-4-4-4-4-5-5-4-5-6- - }

{1-1-1-2-1-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6}  
 {1-1-1-2-1-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6}  
 {1-1-1-2-1-1-1-2-3-3-4-4-4-4-5-5-4-4-5-5-6}

...

Alternatively, we also generated sequences using as transition matrix

*Type 1* | *Type 2* | *Type 3* | *Type 4* | *Type 5* | *Type 6*

<i>Type 1</i>	$\frac{2}{3}$	$\frac{1}{3}$	0	0	0	0
<i>Type 2</i>	$\frac{1}{2}$	0	$\frac{1}{2}$	0	0	0
<i>Type 3</i>	0	0	$\frac{1}{2}$	$\frac{1}{2}$	0	0
<i>Type 4</i>	0	0	0	$\frac{2}{3}$	$\frac{1}{3}$	0
<i>Type 5</i>	0	0	0	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$
<i>Type 6</i>	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{6}$

and also with discrete uniformly distributed initial state

$$\begin{bmatrix} \frac{1}{6} \\ \frac{1}{6} \\ \frac{1}{6} \\ \frac{1}{6} \\ \frac{1}{6} \\ \frac{1}{6} \end{bmatrix}$$

Other sensible variations are under investigation, as well as a comparison with more linear and iterative procedures to generate musical scores, as for instance the Lindenmayer systems described in Pestana [7].

## 4 Conclusions

The proportion of 21 bars scores randomly generated as described that are strictly coincidental with Glass' original — that will be revealed at *Chaos 2012* — is rather less than we had expected in such minimalist setting.

Deeper results may indeed be obtained using higher order Markov chains, assimilating tied pairs of bars or tied triplets of bars with digrammas and

trigrammas as used in mathematical linguistics and its applications to encryption.

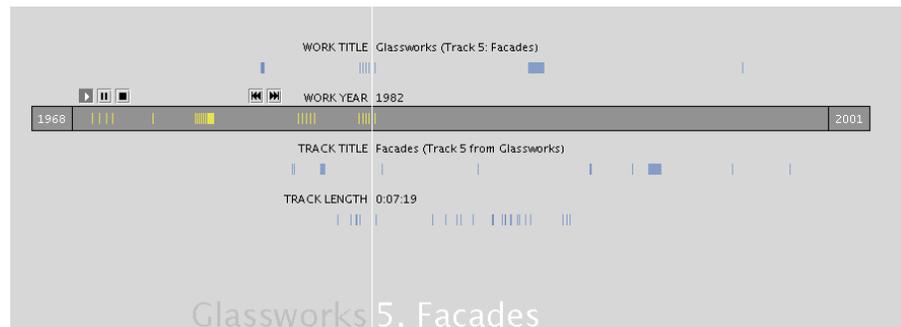
We also observe that a large proportion of the random scores produced using the transition matrix so roughly defined is rather pleasing. Romanticism brought in a respect for the artist and the idea of inspiration that tends to convince us that any modification of an inspired masterpiece cannot but spoil it. On his authoritative *Le Mythe de Rimbaud*, Etiemble [3] reports that in many occasions he recited *Le Bateau Ivre* purposely interchanging lines and blocks of the poem — with no complains from none of the many specialists that fiercely claim that not a single word can be changed in this immortal “chef-d’oeuvre”...

In fact, a subjective evaluation, using our own taste, is that 96.3% of the sequences of 21 bars randomly generated using the transition matrix are reasonably pleasant.

## 5 Appendix A: The IBM Glass Engine

The IBM Glass Engine enables deep navigation of the music of Philip Glass. Personal interests, associations, and impulses guide the listener through an expanding selection of over sixty Glass works.

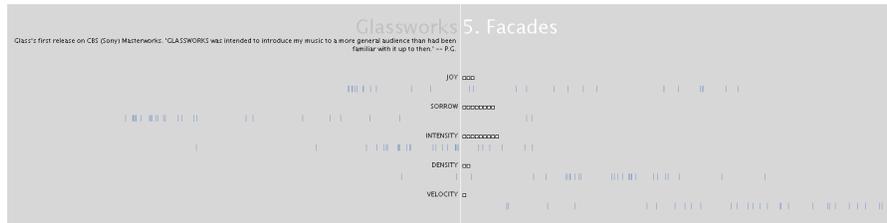
The glass engine was developed at the IBM T.J. Watson Research Center in 2001. You can download it from Phip Glass page <http://www.philipglass.com/music/compositions/facades.php>.



**Fig. 3.** glassengine — locating the track *Facades*.

The answers to two of the Frequently Asked Questions deserve to be recorded:

**Q:** Who decided how to assign the subjective values (such as JOY) to the tracks? Was this done by a computer?



**Fig. 4.** glassengine — assignment of Joy, Sorrow, Intensity, Density and Velocity to the track *Façades*.

**A:** These values were assigned by Philip Glass’s longtime producer and sound designer, Kurt Munkacsi, while eating several pounds of chocolate chip cookies.

**Q:** How is it possible for a track to have high amounts of both joy and sorrow?

**A:** Music can contain two conflicting emotions. Really.

## 6 Appendix B: Koyaanisqatsi

*Koyaanisqatsi, Life Out Balance*, 1982, directed by Godfrey Reggio, music by Philip Glass, “is the first film of the QATSI trilogy. The title is a Hopi Indian word meaning ‘life out of balance’. Created between 1975 and 1982, the film is an apocalyptic vision of the collision of two different worlds — urban life and technology versus the environment. [...] *Koyaanisqatsi* attempts to reveal the beauty of the beast!”

Aside from the MGM release presented by Francis Ford Coppola, (Credits: Music: Philip Glass. Philip Glass Music: Produced & Recorded by Kurt Munkacsi. Conducted by Michael Riesman), you may be interested in *KOYAANISQATSI — Godfrey Reggio — making of*, retrieved in [http://www.youtube.com/watch?v=\\_Mr26\\_m5rGQ](http://www.youtube.com/watch?v=_Mr26_m5rGQ).

<http://www.youtube.com/watch?v=GQsoMIGuPD8> is Part 1/9 uploaded by schipfingerfred in youtube (some other parts have been blocked on copyright infringement rights). Other *url* addresses where parts of the movie can be watched:

<http://www.youtube.com/watch?v=Me7QaFMcQ9A&feature=relmfu>,  
<http://www.youtube.com/watch?v=D1Fg1MgATu4&feature=related>,  
<http://www.youtube.com/watch?v=-iNJ8u4ewD8&feature=relmfu>,  
<http://www.youtube.com/watch?v=M27874iHwpg&feature=relmfu>.

For more information, cf. also the section <http://www.philipglass.com/music/films/koyaanisqatsi.php> in Philip Glass’ webpage.

## 7 Appendix C: Repetition and Innovation in the Philosophy of Music Composition

(Platzner's and a layman description of the musical structure of the form *rondo* to be developed in the full length paper.)

### References

1. Aleixo, S., Brilhante, M. F., and Pestana, D., General stuttering Beta(p; q) Cantor-like random sets. ISI 2011, 58th Session of the International Statistical Institute, 2011.
2. Ervertsz, C. J. G., and Mandelbrot, B., Multifractal Measures. In H.-O. Peitgen, H. Jürgens, and D. Saupe. *Chaos and Fractals: New Frontiers of Science*, Springer Verlag, New York, 1993, 921–969.
3. Etiemble, *Le Mythe de Rimbaud — L'Année du centenaire*, Gallimard, Paris, 1961.
4. Mandelbrot, B., *Fractals and Scaling in Finance; Discontinuity, Concentration, Risk*, Springer, New York, 1997.
5. Mandelbrot, B., *Multifractals and 1/f Noise; Wild Self-Affinity in Physics*, Springer, New York, 1999.
6. Pestana, D., and Aleixo, S. (2011). Stuttering Cantor-Like Random Sets, In Luzar-Stiffler, V., Jarec, I. and Bekic, Z. (eds.), Proceedings of the ITI 2010, 32nd International Conference on Information Technology Interfaces, 29-34.
7. Pestana, P., Lindenmayer Systems and the Harmony of Fractals, *Chaotic Modeling and Simulation (CMSIM) 1*: 91–99, 2012
8. Platzner, F., *Abrégé de Musique*, Ellipses, Paris, 2011.
9. M. Schroeder. *Fractals, Chaos, Power Laws: Minutes from an Infinite Paradise*, Dover, New York, 2009.

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A musical score consisting of four staves of handwritten notation. The notation is in a single system, with each staff containing a line of music and a corresponding line of lyrics in a non-Latin script. The music features a variety of note values, including minims, crotchets, and quavers, with some notes beamed together. The lyrics are written in a cursive hand below each staff. The score concludes with a double bar line and repeat dots at the end of the fourth staff.