A Shattered Perfection: Crafting a Virtual Sculpture

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Abstract

In the development of a digital sculpture for a competition entry, a mathematical approach was investigated as a method to develop a variety of forms. This paper covers the initial inspiration for the sculpture, Georg Nees's Gravel Stones, and then the series of approaches that were developed expanding the starting concept. Each step in the process is described including the decisions and alternatives that were explored. The sculpture was entirely built and developed with custom software using a series of related mathematical concepts. The software and related digital representations became the sculpting material and the sculpting tools.

1. Introduction

Georg Nees's Gravel Stones (Cubic Disarray), created between 1968 and 1971, was the initial inspiration for this series of digital pieces. What attracted me to this piece was the simplicity of the concept and the overall interpretation of transforming order into disorder. This piece is an early example of pen plotter based art, where finely drafted drawings driven by a computer were becoming possible. Gravel Stones consists of an array of 12 by 22 squares. The first row of squares is all aligned next to each other, as each subsequent row is created; each square is randomly offset from its original center and rotated. The offset and rotation is slowly increased till the last row is reached.

What intrigues me with this "ancient" piece was the use of exact mathematical computations to model a chaotic image and the progression from the ordered to the disordered. This piece has greater meaning to me today since many of the recent efforts in developing perfect forms and curved surfaces are of great interest in product design, sculpture, and architecture. Particularly in sculpture, the works of Helaman Ferguson, Charles O. Perry, Robert Longhurst, Brent Collins, Robert Rathburn, and John Robinson all exhibit this quality. All are described in detail by Ivars Peterson [5]. Most of these works are the result of advanced computer software tools and some by related automated manufacturing techniques. Most use a mathematical basis for generating the form in total, or at least portions of it. The sculptures were executed in wood, stone and metal, displaying each to a high level of perfection. In the creating of virtual three-dimensional forms, the advances in modeling and rendering methods have progressed from simply being realistic to being hyper-realistic, perfect beyond the properties possible with real world materials [4]. Even in the digital form generation course I teach, the goal is the same, highly mathematically based forms rendered in some nearly unreal material, Figure 2, [2].

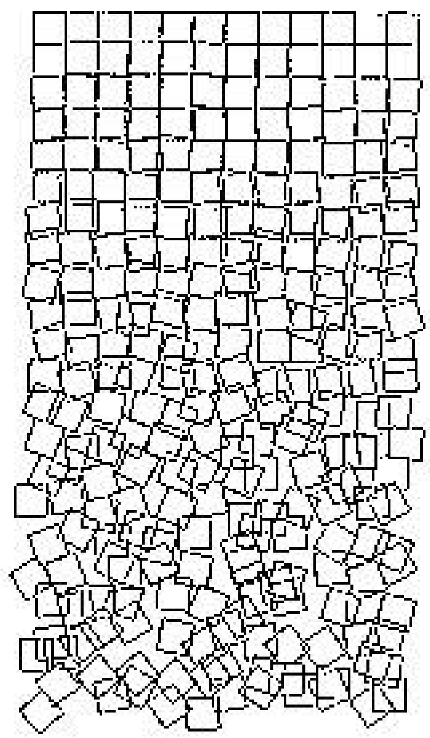


Figure 1. Gravel Stones by Georg Nees

Others have also found this piece an interesting basis for interpretation. William Kolomyjec created two pieces, Boxes I and Boxes II in 1973, Figure 3 [1]. These differ in the direction the progression was taken; inside out and outside in. These pieces were also created as two-dimensional drawings.

I certainly appreciate the beauty of today's near perfect forms and the tremendous artistic vision and craftsmanship it takes to create them. As a personal

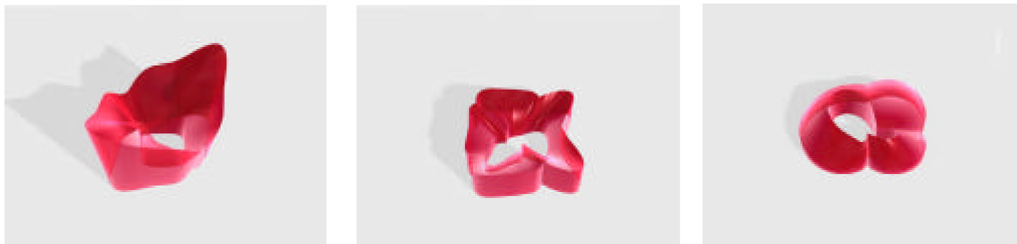


Figure 2. Examples of form generation

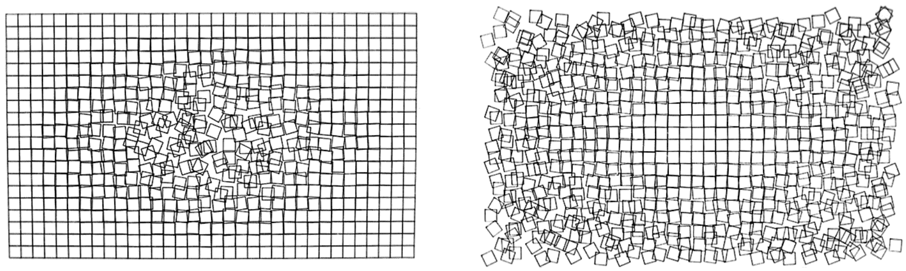
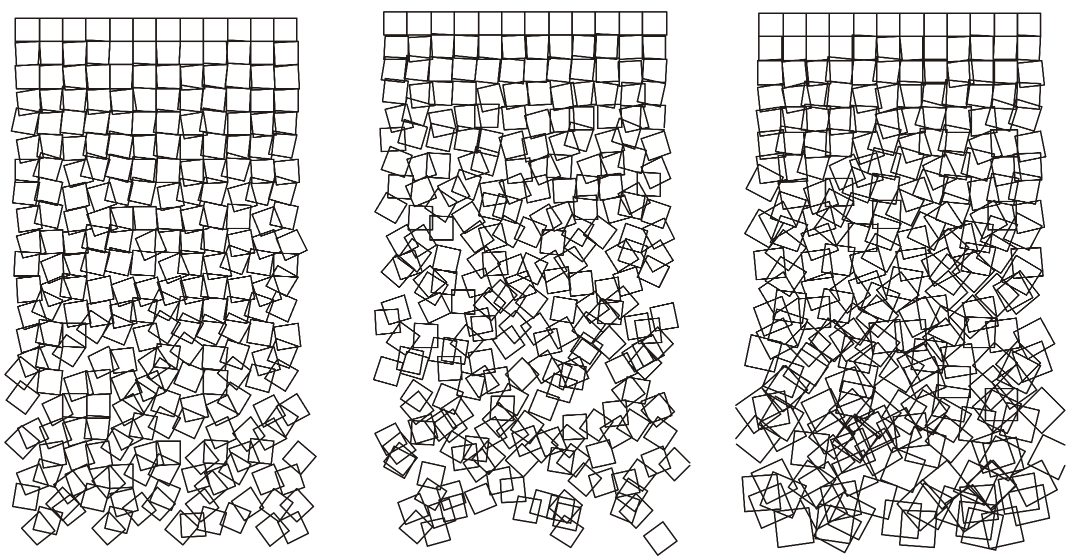


Figure 3. Boxes I and Boxes II by William Kolomyjec



a. **b.** **c.**

Figure 4. Variations to the initial Nees piece

response to this movement towards perfection and beyond, I decided to challenge myself to investigate methods of generating perfection with ones that would shatter it. Using perfection to create imperfection. The goal was to have an underlying perfect framework visible, not just being surface bound.

2. First step

The first set of programs were written merely to duplicate the Nees piece. The same range of parameters was explored. Methods were developed to randomly regulate the square offset and rotation. A variety of offset and rotational parameters were developed. Figure 4 displays a few of these. The first variation, 4a, is very similar to the original Nees piece. The second, 4b, increases the rotation change by a small amount and the offset factor a much greater amount. The third, 4c, investigates the closing of the open spaces between the squares created by increasing the offset factor. In this case, an option is added to also increase the size of the square, along with the other parameters.

Since the goal was a sculptural piece, the next step was to extend the Nees piece into the third dimension. When extending the squares to three-dimensions as cubes, the possibility of varying the vertical dimension became apparent. The first set of variations simply stepped the cubes in an increasing manner. This follows the original arrangement and spirit of the Nees piece.

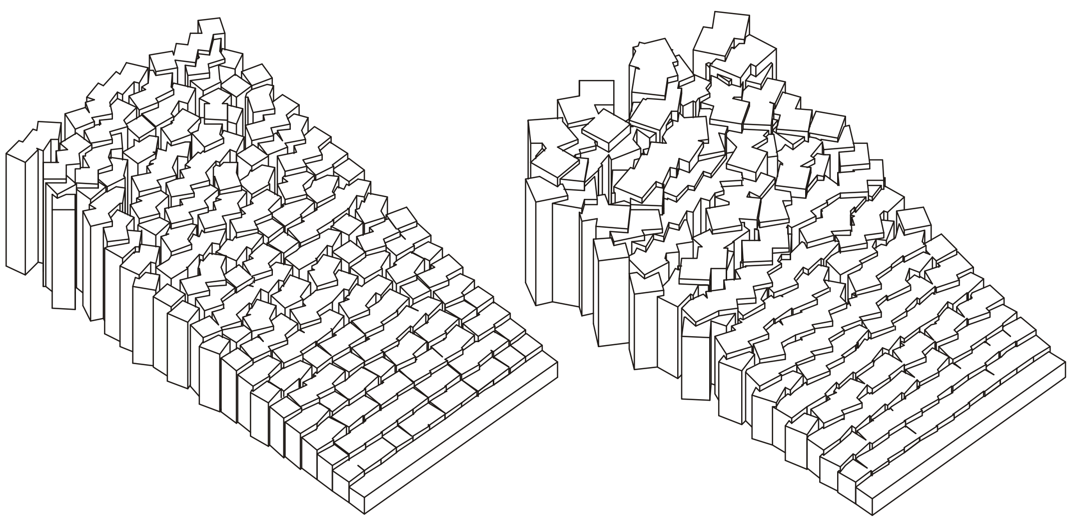
Treating the cubes separately gave the piece the same line quality as in the original Nees piece. When the cubes are combined or unioned, the line quality disappears and the a stepped volume quality appears, as well as, the further definition of the row arrangement. Figure 5 displays two such variations. In 5a, the offset and rotation have small values and the size of the cube is only increased in the height dimension. In 5b, greater variation is included in the offset and rotation, and the size of the cube, length and width, is also increased.

of the each cube was also varied. This now covers all the dimensional and location qualities of each individual cube.

To develop a set of possible directions for increasing and decreasing patterns, a square base form was selected to investigate each. The direction could be increased or decreased with a variety of starting and ending points or edges.

Here are a few patterns that were considered:

a. increasing from one edge to the opposite edge, as in the Nees piece
b. increase from one edge to the center
c. decrease from one edge to the center
d. increase from the corner point to the center point
e. decrease from the corner point to the center point
f. increase from the corner point to the opposite edges
g. increase from the midpoint of the edge to the opposite edge
h. use a curve, as defined as a mathematical function to vary the parameters
i. all random, no orderly increase or decrease



a. **b.**

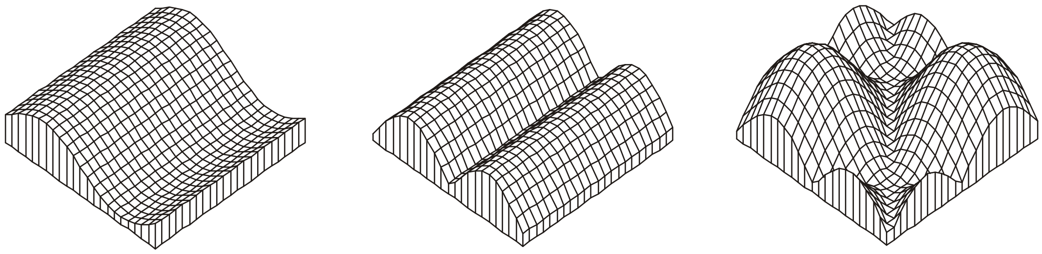
Figure 5. Extending into three-dimensions

3. One step back, one step forward

To further develop this concept, it seemed that a more orderly approach should be taken to better understand the range of variations that were possible. First the variation in the plane of the piece. The offset and rotation were being randomly varied as in the Nees piece. In addition to these two parameters, a third, the size of the cube, length of sides, was being varied. Now all three parameters could be modified in some increasing or decreasing pattern. Since the piece is moving into three-dimensions, the height

Using a square as the basis for the patterns, symmetrical variations could be ignored. These of course could be considered if the base was rectangular as in the Nees piece. In keeping with the Nees piece directional patterns are linear, except for the last two that are random and by function.

The by function pattern is interesting because it enables expanding the Nees piece to include both decreasing and increasing parameters in a single pattern and to change the progression along both the width and the length of the piece. Most of the curves investigated



a. **b.** **c.**

Figure 6. Curve functions

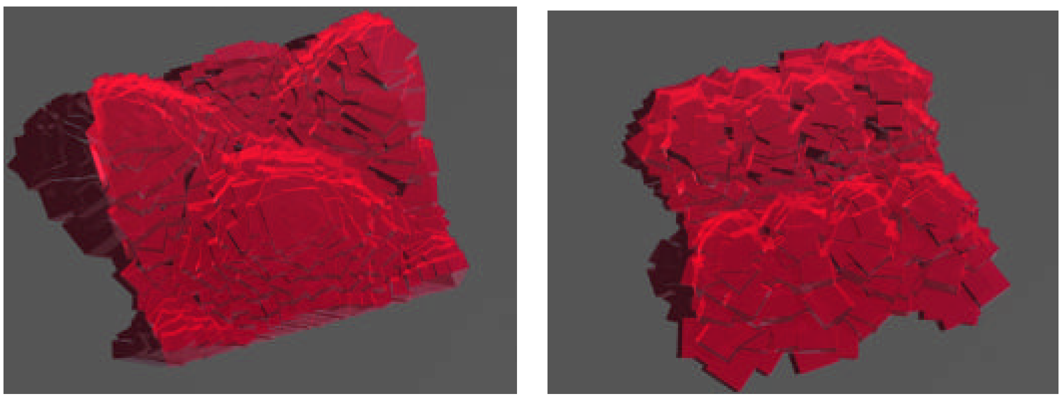


Figure 7. By function variations

are based on a simple combination of sine and cosine functions.

The curve functions also have an inherent set of variations based on their period, the angle covered over some distance. The first assumption was that the function starts at 0 degrees and ends at 360 degrees over the entire length and width of the piece. As the total angle is increased from 0 to 720 degrees or decreased from 0 to 180 degrees, the curvature is extended or compressed over the piece. Of course the starting angle does not have to be 0, it could be any angle, so any specific portion of a curve could be captured.

Some functions have the unruly behavior of decreasing to a negative height. Two methods were developed to deal with those, one was to introduce a minimum cube height so the piece is always above a base, or simply take the absolute value of the function so it never decreases below the base.

Figure 6 displays a series based on the sine curve, the absolute sine in one direction, and absolute sine curve in both directions.

From these parameters an initial set of pieces were created, as shown in Figure 7.

4. Continue forward

The possibility of symmetry using a square base was very appealing but fairly predictable after a few variations. A rectangular base was tried again, but a similar conclusion was reached. The square form did give a compact form that was desired, so other basic compact forms were investigated. The first in the series was a circular form. The circular base modified the effect of direction because of the radial lines starting at the center and ending at the outside edge. The concentric lines have the additional property that the starting and ending points are the same. Because of the limited number of possible edges the directional patterns were found not be extensive. To increase the number of edges, an inside edge was added, resulting in a ring form.

Figure 8 displays a few of the directional variations developed on the circular base. This study included a variety of increasing and decreasing directions, both radially and concentrically. A number of by function combinations were investigated to see what the entire range of using the circular form could be. Once the initial studies were completed, a few final sketches were developed, Figure 9 displays three variations of the circular base and the ring concept.

A number of sketches were developed until a final form was found. Figure 11 displays “Shattered Perfection 1304”, the entry for the digital sculpture competition. 1304 had a great variety in the underlying surface and the shattering of the surface matched the visual effect that was desired. The final piece was also compatible with rapid prototyping equipment, one of the requirements of the competition.

The last variation that was considered and not fully developed was the shape of each element that breaks the surface. It does not need to be in the shape of a cube. Others were considered, circular, triangular, hexagonal, pentagonal, and octagonal. None of these seemed to break the surface with such sharpness as the square did. These other shapes also did not overlap enough to form a single larger volume or they had so many edge points that they introduced an undesired softness to the piece.

5. Look back

Writing software to create a form is very similar to the process of sculpting – material, existing media, is subtracted from or added to in constructing a form. In software, nothing exists at the beginning, the process is first additive and then subtractive. The software you use does to some extent, as real materials, determine what you can do. By this I am referring to the geometric entities are included to create volumes. This might include the construction of simple volumes; cubes, spheres, torus, or surfaces. You can take advantage of simple operations to construct complex forms. For example, creating a bezier

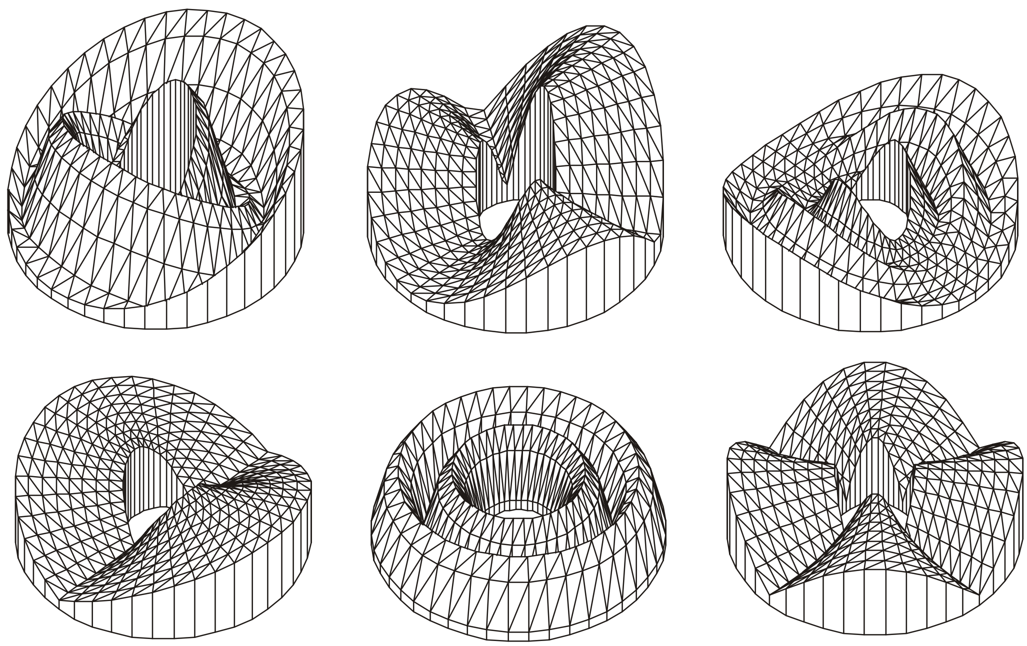


Figure 8. By function pattern variations on a circular base

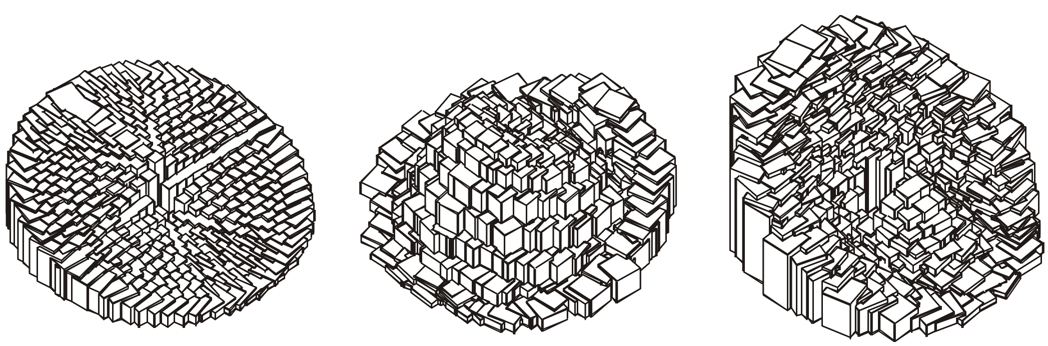


Figure 9. Variations on a circular base

curve from a set of points or line segments and then using that curve profile to create a surface. The software environment which you select can actual enhance the possibilities either related to the properties of real materials or some that are unique to digital representations. Of course, the limitations of virtual forms are few, but when you decide to realize them, the material choices can limit the form. The question that begs to be asked if they need to be realized at all.

It is very interesting to take a finite set of elements that have a finite set of parameters that can be constructed in a predictable manner individually but not so when combined. Another interesting aspect of this approach is the repeatability of results. This is critical to better understand the total concept you are investigating and also in developing an idea in an orderly fashion - if you choose to. It is important to me to have a rational underpinning of the work I produce. Software enables me this type of tool – to such a degree that producing the pieces physically have little interest many times.

I have also found that conceptual art was been a rich resource for developing and better understanding digitally based art. A good starting point has been the description of conceptual art as developed by Sol LeWitt:
"When as artist uses a conceptual form of art, it means that all of the planning and decisions are made beforehand and the execution is a perfunctory affair. The idea becomes a machine that makes the art" [3]

In my reading of his notes, he has a desire to create a "machine for art" by describing the patterns that comprised a concept. How does this differ from developing art with software? The artist concentrates on the development of the concept and the ideas within it. All of the parameters are defined and computational methods are developed to support a particular concept. The computer instructed by the software actually creates the piece. There is a great parallel here with the crew and drafters that create some of LeWitt's work. The conceptual aspect of digital art is an area that has few limits. With the large number of mathematical concepts that can be applied to generating forms, the possibility of developing the unexpected is great.

6. References

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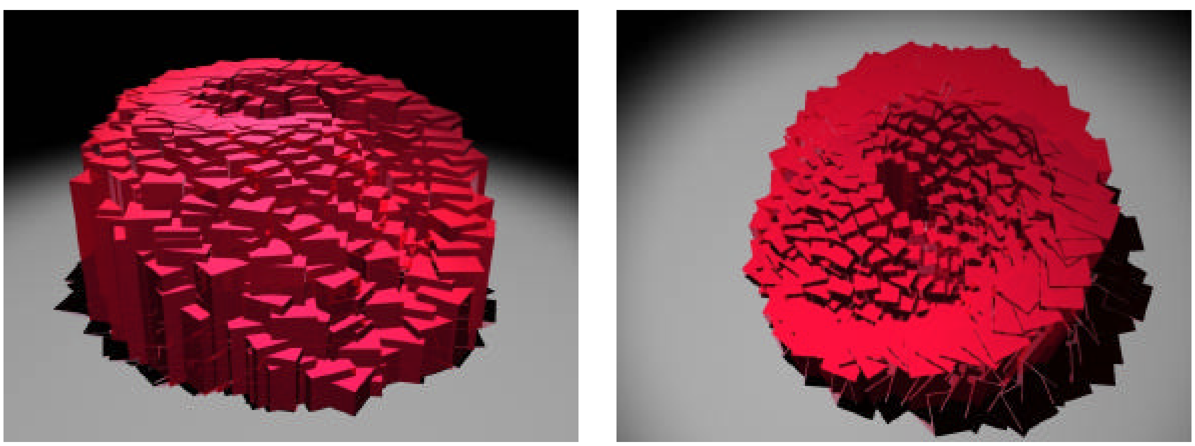

Figure 10. Shattered Perfection 1304