The Art of Equations

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Abstract

From the soft-edged apple peels to the bird of paradise and leaves, from the hard-edged durians to desert cactus and coccothrinax, all can be formulated entirely by a 3-equations foundation. That is, one equation for each axis (x, y, z). The software auto computes the coordinates for each of the x, y and z axes as well as a varying real-time driven surface color and lighting parameters. Equations can be shaped to generate nature-like plants, birds and bees, marine creatures and 3D objects, to formulate Balinese face masks, kimono and obi belts. These generated 3D structures can be animated and morphed automatically, and it can be Web-enabled.

When creating surfaces for the same object, equations are preferred over 3D modeling as it is extremely scalable and it is implemented with lean computational resources in hardware, software and manware, in fact, it is the minimum. This economy of expression is also the most flexible in real-time driven continuous facade changing for 3D geometry. It is an ecological purification of mathematically generated bit streams. This paper presents the results of an array of 3D structures formulated by equations.

Keywords: 3D geometry, 3D modeling, equations, surfaces, digital sculptures, animation

1 INTRODUCTION

Conventionally, virtual sculpting is based on 3D modeling techniques [1]. Fundamentally, 3D modeling or volume modeling techniques are capable of modeling objects with possible changes in topology. A common practice is to provide shape editing tools for adding or removing voxels from a volume model. Nevertheless, this techniques is basically resource intensive even for creating an object with average complexity.

Away from the volume modeling techniques, this paper discusses, presents and demonstrates the results of an array of 3D digital or virtual sculptures and structures formulated polynomial equations, based on the fundamental theorem of algebra.

2 THE APPROACH

Be it 2D images or 3D objects or sculptures, creating artworks begin with visualization regardless of the media, conventional medium or digital. With some rudiments of algebra, it is not difficult to write some simple equations to draw a curve, or shape a simple form. Hence, visualization of equations is a serious medium for creating a great variety of artworks with tremendous diversity through a combination of human creativity and computer power. A 2D image is actually a polynomial graph based on the use of iteration functions algorithms for solving polynomial equations. In the creation of an artwork, the artist may employ the mathematical properties of the iteration functions or those of the underlying polynomial, or both. This method, or polynomialgraphy [3] can be considered as *painting via points* -- an art form capable of creating an interesting variety of images by manipulating a finite set of points, whether given explicitly or generated by a polynomial equation. In other words, a polynomial equation is an algebraic description of a set of points in the Euclidean plane, namely, its roots. Conversely, any set of points in the Euclidean plane can be written as a polynomial equation having those points and only those points as solutions. Extend this concept to sculpting, a 3D volume or object are polygons with more than 2 axes created by multiple polynomial equations. In this case, an experienced sculptor can shape the equations to create desirable forms, or generate sculptures with enormous complexity.

Whether organic or otherwise, all forms are built by equations based on fundamentals. For example, Nautilidae and turritellidae are based on reciprocal spiral (hyperbolic spiral – the inverse curve of Archimedean spiral) or Fermat's spiral (parabolic spiral). A swirl is an involute of a circle. Combinations of different mathematical functions with unusual parameters can result in interesting forms, shapes and surfaces. To create a form:

i. outline the contour of a desired form
ii. understand, remember and match the curve of a given mathematical function to the contour of the desired form
iii. refine the 3 equations
iv. iterate step iii to your satisfaction

3 MATHEMATICAL ART: SYMMETRY, REGULARITY vs ORGANIC

Ricardo Zalaya Báez in his proposal for the classification of mathematical sculpture [4] categorizes them by geometrical sculpture, concepts of calculus, algebraic concepts, topological sculptures and sculptures with different mathematical concepts, each of these with several subcategories, whereas others discuss mathematical art by symmetry[5], symmetry, motion and form [6]. Whatever the classification and classification method may be, there is a strong tendency to equate, correspond or even identify mathematical art with the primary notion and/or objective with symmetry and less organic or rather non-organic, in general. This is clearly pointed out by Michael Betancourt in his article on taxonomy [6], where he describes the distinction between organic/geometric forms "emerges as a direct result of the degree and character of the curvature of the form.", thus it is important and necessary to understand and discern what symmetry is and isn't, dispel and discard highly misconstrued information and hence relish the capabilities and strength of equations.

4 THE ARTWORKS

From the soft-edged apple peels to the bird of paradise and leaves, from the hard-edged durians to desert cactus and coccothrinax, all can be formulated entirely by a 3-equations foundation. Beyond asteroids, cardioid, deltoids, ellipsoids, lemniscate of Bernoulli or Gernoro [7], equations can be shaped to generate nature-like plants (Figure 1), birds and bees (Figure 2), marine creatures (Figure 3) and 3D objects (Figure 4). Beyond the conceivable Nautilidae and turritellidae, equations can be used to formulate Balinese face masks (Figure 5), kimono and obi belts. The equation-based software auto computes the coordinates for each of the x, y and z axes as well as a varying real-time driven surface color and lighting parameters. Thus the generated 3D structures can be animated and morphed automatically, and it can be Web-enabled.
Presented here are 5 categories of forms, viz: architecture, plants, marine creatures, objects and human forms (Figure 6).

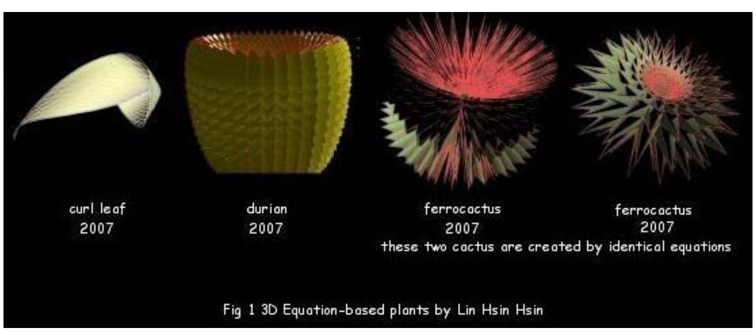

Fig 1 *Equation-based plants by Lin Hsin Hsin*

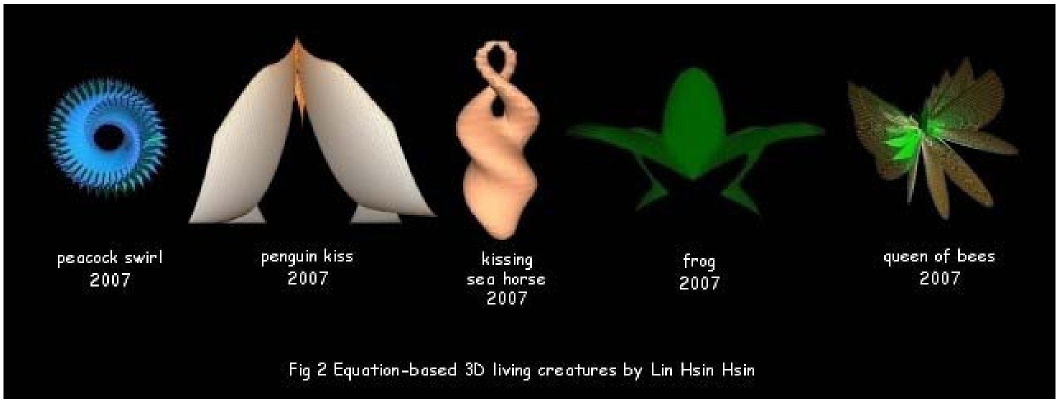

Fig 2 *Equation-based living creatures by Lin Hsin Hsin*

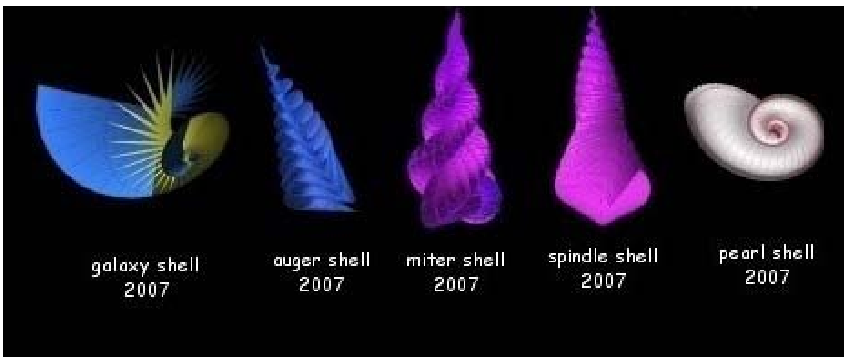

Fig 3 *3D Equation-based Nautilidae and turritellidae by Lin Hsin Hsin*

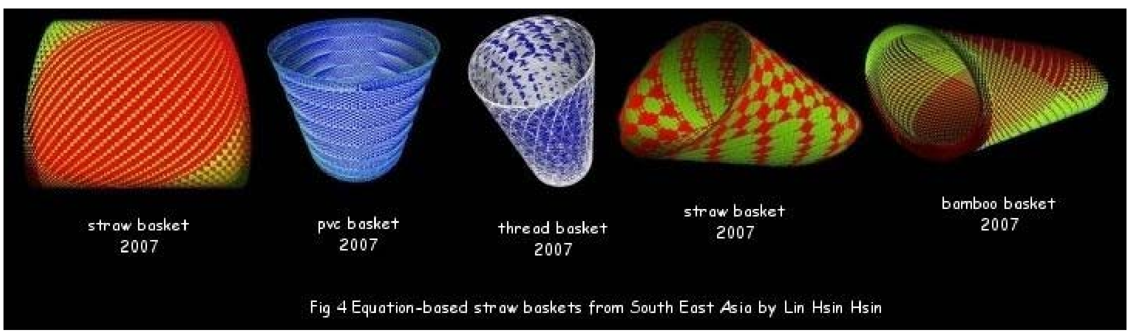

Fig 4 *3D Equation-based straw baskets from South East Asia by Lin Hsin Hsin*

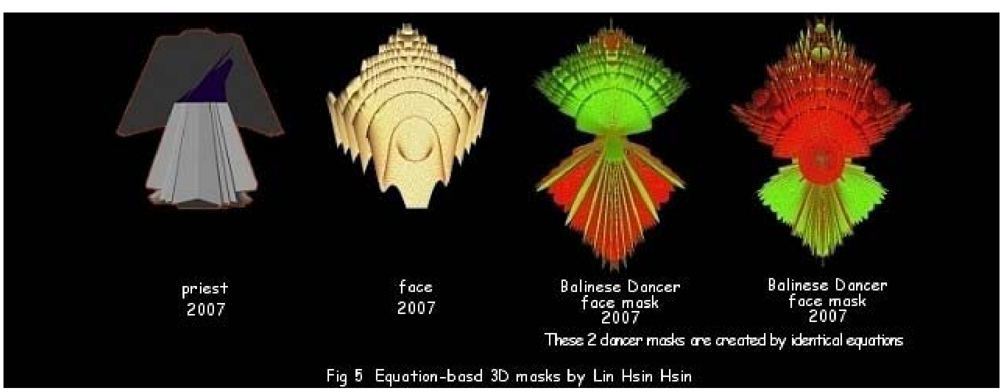

Fig 5 *Equation-based 3D masks by Lin Hsin Hsin*

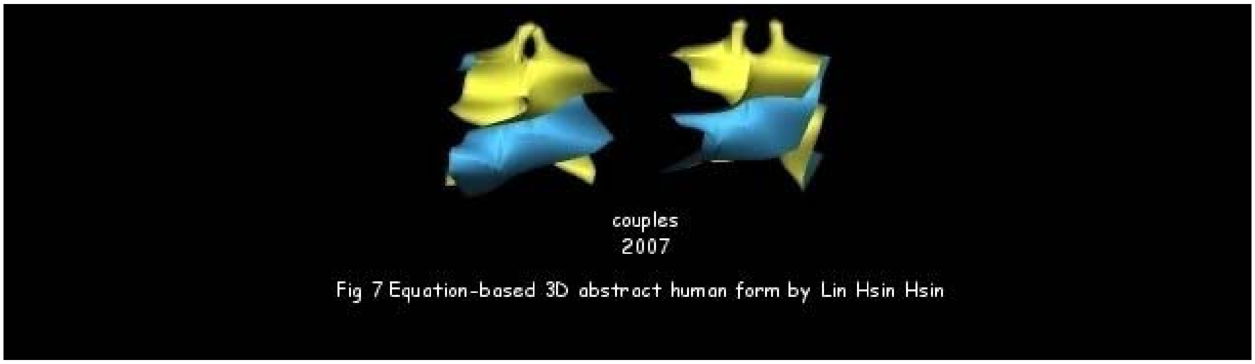

Fig 6 *Equation-based 3D abstract human form by Lin Hsin Hsin*

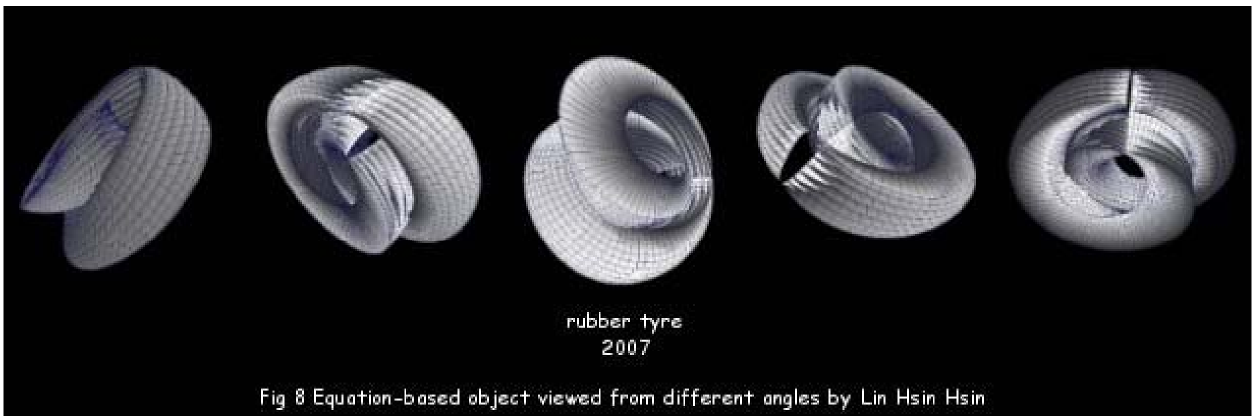

Fig 7 *Equation-based object viewed from different angles by Lin Hsin Hsin*

5 CONCLUSIONS

When creating surfaces for the same object, equations are preferred over volume modeling as it is extremely scalable and it is implemented with **lean** computational resources in hardware, software and manware, in fact, it is the minimum. Quite often, it is initiated, created and implemented by one person versus a team, using a laptop with less than 1GB memory, power up on a 1GB kernel Linux software with compute time as little as less than 10 seconds for a simple structure (Figure 7). This economy of expression is also the most flexible in real-time driven continuous façade changing for 3D geometry. It is an **ecological purification** of mathematically generated bit streams.

References

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