Mathematical Photography: A Creative Pursuit

By Prof. Biswatosh Sengupta
Photographic Association of Dum Dum
Kolkata, India

"Jatha Shikha Mmayuranang Naganang Manayo Jatha
Tad Bat Vedanga Sastranang Ganitang Murdhani Sthitam"
- Vedanga Jyotisha

(Like the crest of the peacock, like the gem of the snake so is Mathematics at the head of all knowledge)

Introduction

Since the dawn of civilization man has been interested in the mystery of creativity. His pleasure in aesthetics has inspired him to recreate the beauty of this wonderful world through intuition and imagination. Man has used various tools in a bid to create objects of art; be it the pen of the writer, the brush of the painter, the chisel of the sculptor or more recently including the camera of the photographer. In my opinion photography, in spite of being the youngest of all visual arts, has emerged as the most powerful medium of creative satisfaction. Technological innovations in recent years have further revolutionised the process. Pictorialists in their creative pursuits are often at the forefront of using different modern tools and techniques.

Mathematical Photography

Mathematical photography is the term I have given to a creative process combining both mathematics and photography, where one creates artistic photography with the aid of Mathematics. Here both the journey and the destination are fascinating. Photography is a scientific process of sketching with the help of light. Photography, which was earlier a combination of Physics and Chemistry is at present an amalgamation of Physics and Digital Technology. Interestingly, the Physical, Chemical and presently the Digital principles of photography are all dependent on Mathematics. Particularly, digital photography which rests on binary digits 0 and 1 and is based on intricate mathematics; starting from Pixel matrix forming the image of the subject to complicated mathematical functions used in Digital editing. Moreover, at every stage of photography, whether analogue or digital, calculation of exposure, guide number (flash photography), intensity of illumination, adjustment of focus, image size (magnification), DOF, angle of view, perspective, f/ number, shutter speed, preparation of developer maintaining the ratio of chemicals etc., need to use mathematical formulae for efficient performance. Thus the mechanics of photography cannot be devoid of mathematics. The canons of artistic composition, like the rule of thirds and the golden points, the Golden spiral, the Fibonacci Spiral or the divine proportion 1:1.618 ("PHI") or Pi are all based on geometry. Artists across ages have used geometrical shapes to make their creations aesthetically pleasing. Photographers also deliberately make use of such shapes either physically (actually visible in the picture) or virtually (conceived with imaginary lines) to make their works stand out.

Some Other Comments

Mathematics is everywhere in nature. For example, the path traced by the planet Venus every eight years, is a perfect pentacle. In my opinion, probably the best creation in nature is the human being. The anatomical structure of a human is an illustration of mathematics in form and function. Great artists like Leonardo da Vinci, who was also a polymath, have often been inspired to create the perfect human form in their works. His famous sketch the 'Vitruvian Man' set out very specific mathematical proportions. This principle was also followed by another master – Michelangelo - in his creations,

particularly in the statues of David and Moses. In music, Beethoven also applied mathematical rules while composing his fifth symphony. The intellectual relationship between mathematics, music and art can be deduced in the works of many a great artist. The names of Iannis Xenakis, Wassiliy Kandinsky and Arnold Schoenberg are worth mentioning in this respect. The correlation between art and mathematics can be drawn, firstly, from the works of Iannis Xenakis, the Greek composer, architect and mathematician, who used computer programmes to compose music based on mathematical probability systems, and secondly from the paintings of Wassiliy Kandinsky, the famous Russian abstract painter. In fact, Xenakis corresponded mathematical models to music and Kandinsky to frequencies of colours; something logical since both music tones and colours can be analysed by or transcribed to mathematical formulae. Kandinsky found parallel lines between Austrian composer and painter Arnold Schoenberg's serial and atonal music and his own paintings. After having attended a Schoenberg concert he tried to sketch the performance. His final painting "Impression III (Concert)" fused colour and sound in a synaesthetic experience that marked their collaboration in the field.

The pyramids of Egypt are a perfect example of geometry, mathematics again! The keystone of an archway of a church or other old architectures carry the weight of the whole thing, which is polyhedron in shape.

Towards My Creations

The body of work created by the author makes wide use of various mathematical formulae viz. Algebraic and Trigonometric functions, rippling, normal distribution, complex numbers, fractals, Voronoi diagram, TSP (Travelling Salesman Problems) etc. with different algorithms using various computer languages and software like C++, Matlab, Apophysis, Python, Daz3D, Stippling Gen, etc. Such programs were used for generating various shapes and patterns. The human figures were mostly generated using Daz3D. Finally, Photoshop was used to combine the images taken with the camera and the shapes generated digitally to produce what I call "mathematical photography" so that it becomes thematically and aesthetically pleasing. Some candid shots from Greece, France and Italy and few others from the old stock chiefly constitute the photographic elements. In some cases the fascinating Photoshop filter for polar to Cartesian transformation or vice versa have been used for creating odd and humoristic visuals.

Methodology and Classification of My Works

Earlier, in my two solo exhibitions on Graphic Art and Digital art, held in 2010 and 2013 respectively, extensive use of C++ language was made to create most of the pictures. Matlab and Daz3D were also applied in some cases. The present creations use the same software, mostly Matlab. In spite of pre-visualisation of the final image a lot of trial and error was involved, as it is impossible to conceive the end result that the software produces. Various mathematical shapes and patterns, viz. multiple circles, rectangles, triangles, diamonds, spheres, ellipsoid, etc, have been generated either by writing new programs or by changing parameters and number of iterations of the inbuilt programme for Voronoi diagram and other available programs. Apart from programs mentioned earlier, Apophysis has been used to generate enormous random fractals, which were then changed as per the aesthetic demands of the pictures. A TSP (Travelling Salesman Problem) programme developed by my students Dr. Ammlan Ghosh, Mrs. Adrija Bhattacharyya and Mr Bidyut Gupta under my guidance has also been widely used. Another freely available software calculating Voronoi diagram, viz. Stipple gen2, has been used to create dots and circles for an interesting representation of the picture, enhancing the aesthetic value.

1. Guard (Voronoi)

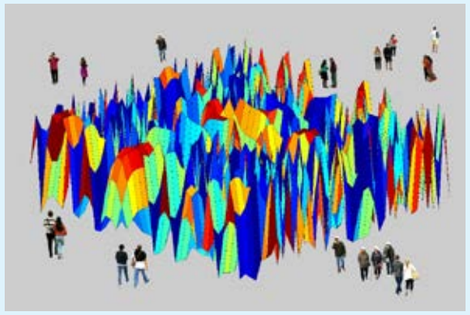
Articles

Various types of backgrounds using a lot of mathematical calculations have been created for the exhibited pictures.

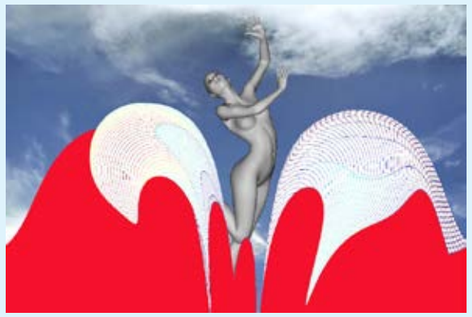
The work can be classified into four categories as follows:

1. Initially, various mathematical patterns, shapes and forms were randomly generated using various techniques as mentioned earlier. From these patterns, forms and shapes, those resembling the known elements of this mundane world were selected and then combined with the camera images to create images that are thematically meaningful and aesthetically pleasing. This was followed by Digital editing with computer manipulations following SEA (Selection, Elimination & Addition) rule of ART for the final image. P1 is an example of Voronoi; P2 is an example of Fractals and P3 is an example of Rippling.

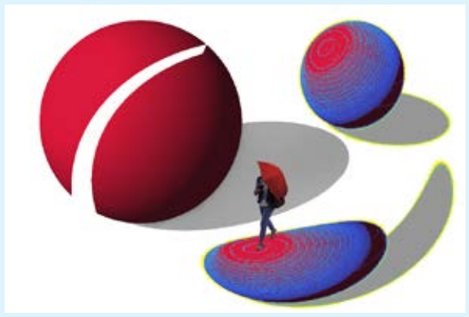
2. Ultimate Desire (Fractals)



3. Rippling Mass (Rippling)

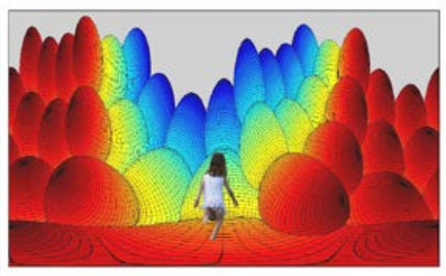


4. Heavenly (Mathematical Curves)



5. 3D-Sphere (Mathematical Curves)

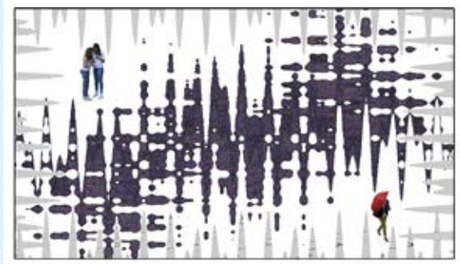
6. Life Is Beautiful (Mathematical Curves)



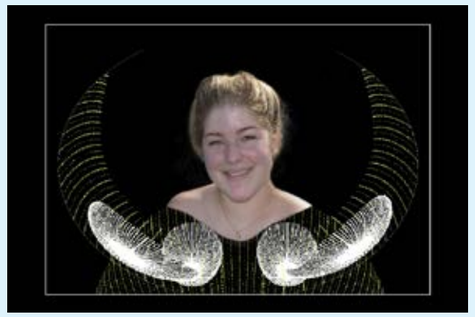
7. Towards The Eternity (Mathematical Curves)

2. At the next stage, a few regular geometric shapes were drawn, which were combined with camera shots to enhance the overall composition and beauty of the pictures. Some trials were needed to determine the thickness, dimension and number of lines of the curves according to the feature of the subject depending on the available space. Then such forms were combined with the previsualised images with a suitable background to convey the meaningful thoughts. P4, 5,6,7,8,9,10 are a few examples of this category termed as Mathematical Curves.

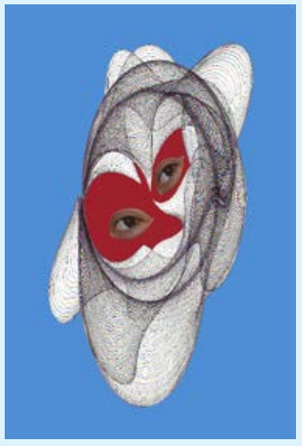
3. The third category, TSP (Travelling Salesman Problem) and Stippling, are totally different but interesting. The application of TSP in the field of photography has been available for quite some time. Different continuous lines used in my mathematical photography were generated using a program developed by myself and my students, as stated earlier. Variances can be made in the number of "City Centres" (see TSP explanation in Appendix), line-width, line-style and colours. This too involved a number of trials by varying parameters to find out the best visual effect. A few fantastic continuous outlines were generated and then edited and combined with a suitable background and the original image, or part thereof, with Photoshop. P11,12,13 are a few examples of Mathematical Photography using TSP. For creating dots and circles, Stippling Gen2 was used. Using the software one can produce a TSP path and Stipples but here one's flexibility is limited as there are very few options to manipulate. However, pictures like Shanti (P14) and Happy moments (P15) were created using the tool.



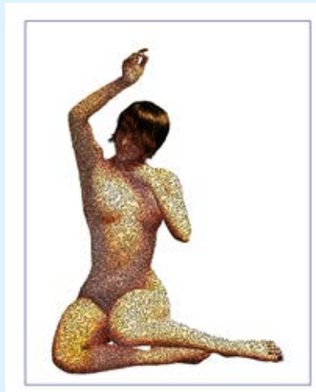
8. Reflection (Mathematical Curves)



9. Smile Please (Mathematical Curves)



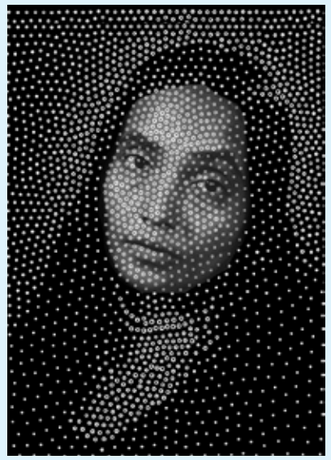
10. Face (Mathematical Curves)



11. Figure Study-002 (TSP)

12 Sketch Avik (TSP)

13. Ansester1 (TSP)



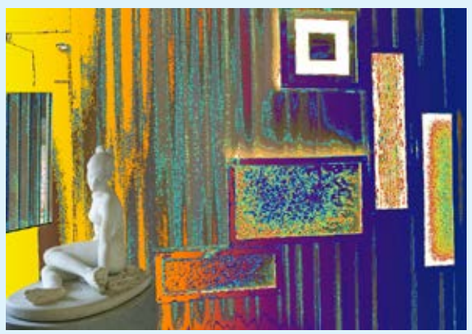
14. Shanti (Stipple)

4. The fourth category includes those images which themselves contain mathematical shapes in the pictures and/or those which could not be included into the above categories but have potential to get converted to mathematical photography by marginal digital manipulation and utilisation of appropriate background already generated. P 16-20 are a few examples.

16. ET

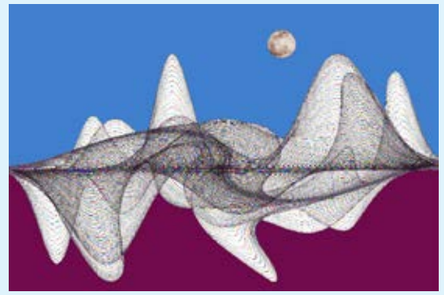
15. Happy Moment (Stipple)

17. Geometry



18. Window

19. Dance SFinal



20. Moonlit-019

Conclusion

Mathematics plays a very vital role in every sphere of our life and so does art, of which photography is one of the media. The profound relationship between the two can be found in the works of two giants of the fields, namely Albert Einstein and Pablo Picasso. Picasso never met Einstein, but he created 'Les Demoiselles d' Anignon, which contained the seed of cubism, which was Einstein's concept of geometrical symmetry in the General Theory of Relativity. It is said that if God and Truth are synonymous, there may be a number of ways through which the destination can be arrived at. Photography as a medium can play a pivotal role in bridging the gap between Mathematics and Art to create masterpieces.

Mathematical Photography as a creative pursuit has a vast potential in creating fantastically wonderful pictorial photography. Let Mathematical Photography flourish with the intuitive and imaginative mind of the artists utilising the various mathematical tools to produce aesthetically pleasing creative images.

Acknowledgements

I express my sincere gratitude to those who directly or indirectly helped me in preparing this article.

Appendix

Terminology used:

Voronoi- a diagram, in mathematics that is a partition of a plane into regions close to each of a given set of objects. In the simplest case, these objects are just finitely many points in the plane (called seeds, sites, or generators).

Fractals- a curve or geometrical figure, each part of which has the same statistical character as the whole. They are useful in modelling structures (such as snowflakes) in which similar patterns recur at progressively smaller scales, and in describing partly random or chaotic phenomena such as crystal growth and galaxy formation.

MATLAB is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

Apophysis has many features for creating and editing fractal flames, including an editor which allows one to directly edit the transforms by manipulating triangles, a mutations window, which applies random edits to the triangles, an adjust window, which allows the adjustment of colouring and location of the image

Travelling salesman problem (TSP) asks the following question: "Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city exactly once and returns to the origin city?"

Stippling is the creation of a pattern simulating varying degrees of solidity or shading by using small dots. Such a pattern may occur in nature and these effects are frequently emulated by artists.