Density Plots with Mathematica and Innovative Graphic Designs Suitable for Textile Industry

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Abstract—It is observed that density plots of any mathematical function, being an arrangement of shades or colours in rectangular meshes is an image which can actually be implemented on different types of looms. Further, it is noted that using some simple techniques and simple properties of Mathematics, beautiful and innovative graphic designs can be created. A few such designs are actually created by using the density plot command from Mathematica. These designs are innovative in the sense that instead of conventional 4 –fold, 6-fold or 8-fold symmetries, these designs display 3-fold, 5-fold or 7-fold symmetries.

Keywords— Mathematica, Density Plot, Graphic Design, Textile Industry

I. INTRODUCTION

Any design or pattern that is given as an arrangement of colours or shades in the form of a rectangular mesh can easily be transferred and implemented on many types of looms and can be readily used in different types of Textile Industries. It is noted that density plot of a mathematical function is an arrangement of shades (default- greylevel) in an rectangular array and therefore any density plot is well suited for implementation in Textile Industry. Mathematics is a rich source of patterns and symmetries. We have tried to explore this vast ocean of mathematical functions to get some innovative designs suitable for upholstery, blankets, carpets, bedcovers etc.Our designs are innovative in the sense that instead of conventional 4 –fold, 6-fold or 8-fold symmetries, these designs display 3-fold, 5-fold or 7-fold symmetries. The feasibility of using designs based on Fractals in the Textile Industry is also explored.

II. PRELIMINARIES

The software 'Mathematica' has been used to create our designs and the main focus is on the density plot command of 'Mathematica'.

A. Density plot in 'Mathematica'

Consider a function $f : R^2 \rightarrow R$ defined over a rectangle R in the x-y plane. The range r of f in R is defined as $r = Maxf - Minf$ In the command **DensityPlot**, a number of plot points, say n are chosen. *Mathematica* divides the rectangle R into n×n sub- rectangles. For each k, a point P is chosen in the kth sub-rectangle. Each point in the kth sub-rectangle is assigned a number $(f(P) - Minf)/r$ which lies between 0 and 1. This number is called the height number of the point. The default coloring for **DensityPlot** is **GrayLevel**, each point in the rectangle is assigned the color **GrayLevel**[$(f(P) - Minf)/r$].

B. Examples of Density Plots:

Consider the function

$$z = Cos\left(\frac{1}{x^2 + y^2}\right), x \in (-0.4, 0.4), y \in (-0.4, 0.4)$$

Its density plot in default greyscale is given below (Fig.1.).

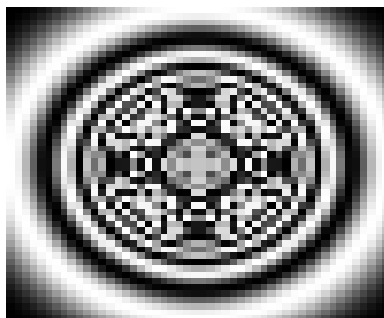**Fig.1.**

Consider the function $z = Sin\left[Cos\left(\dfrac{1}{x^4 + y^4}\right)\right], x \in (-1,1), y \in (-1,1)$

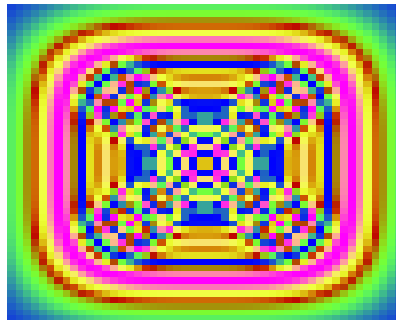Its density plot with a colouring scheme is given below (Fig.2.).

Fig.2.

III.   THE METHODOLOGY

The methodology consists of finding good mathematical functions whose density plots are beautiful and innovative designs. Usually it is a very laborious process and a lot of trial and error goes into it. Many bad designs are to be discarded before actually hitting upon a good innovative design with the desired effect. Various challenges in the process and strategies to overcome them are listed below:

A. The Challenges:
   (i) To choose the underlying mathematical function .
   (ii) To choose or create the appropriate algorithm.
   (iii) To choose an appropriate coloring scheme.
   (iv) The feasibility of actually putting these designs to industrial use.

B. To choose good Mathematical functions for innovative designs we usually follow the following strategies :
   (i)   Rely on intuition
   (ii) Apply some simple Mathematics to choose functions for a pre conceived attributes of the designs

C. Strategy to obtain innovative designs depicting unusual symmetries:
   In order to obtain density plots with 3-fold, 5-fold or 7-fold symmetries, we use functions involving odd powers of a complex number. This strategy is based on the well known fact that nth roots of any complex number are symmetrically placed on the circumference of a circle.

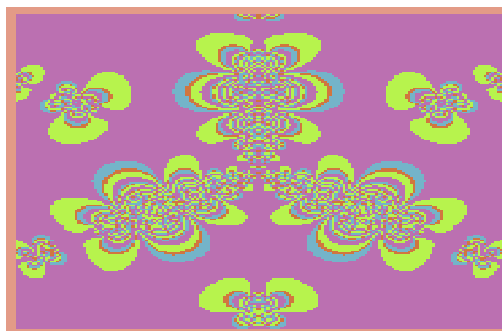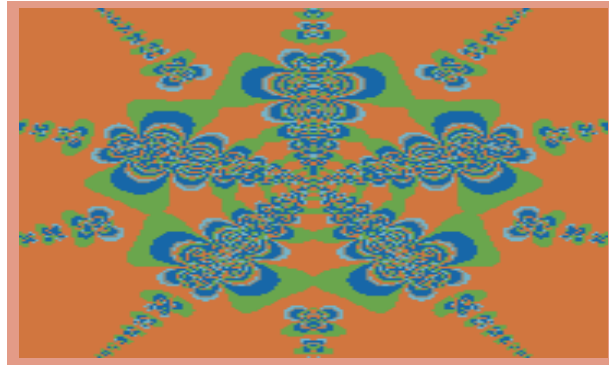**D. Some innovative designs:**
   Innovative design 1:

Fig.3.Three fold symmetry

Innovative design 2:

Fig.4. Five fold symmetry

Innovative design 3:

Fig.5.Seven fold symmetry

E. A fractal based design:

Julia curves of functions of a complex variable are fractals [1][2]. A well known technique to draw approximations of Julia curves is escape time algorithm [3]. As this technique renders the fractal as a density plot, we can use these fractals and Julia curve based designs in the textile industry. A sample such design is reproduced below in Fig. 6.
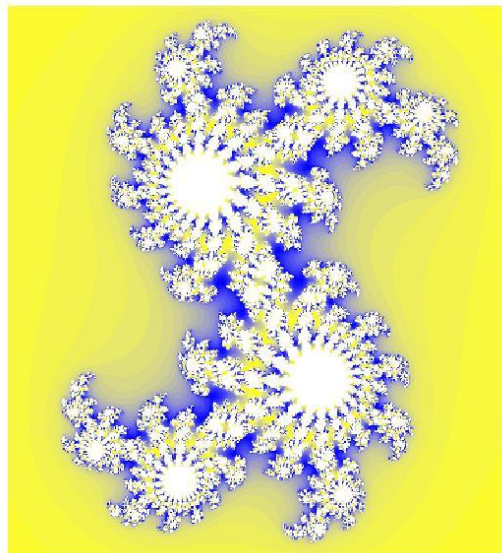

Fig.6. A fractal based design

IV. CONCLUSIONS

Commercially viable innovative designs for use in various industries can be made by applying the knowledge of Mathematics along with some computer graphics programming skills and creativity.

Remark: The designs depicted in this work are pure in the sense that these are just the density plots of Mathematical functions and no editing like adding layers or masks has been done, as is being done by many graphic artists these days [6][7]. This leaves a lot of scope for the computer artists to experiment further.

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