Design with Mutant Modulation Screen Elements

Jana Z. Vujic; Klaudio Pap; Ivana Ziljak

The area of individual screening has a wide field of application from designing the graphics of documents and securities to independent designer actions. In this paper new screen elements (SE) have been given systematically and their border conditions have been researched in respect to the design of contemporary computer graphics and reproduction. Screening is concentrated on stochastic method application. The method of pseudorandom choice of the screen element shape has been introduced, as well as that of rastering frequency choice, and rastering angle choice. The area of mutant SE is introduced; i.e. the SE that change their shape depending on the halftone range.

In case of reproducing a color image the possibility is stressed to design programmed joining of different color channels with choise of SE. It is proposed to use positive and negative deformation of SE from the same set, and in the same position for different color channels. The paper gives algorithms that rip the image and its image elements through new mutant screen elements in order to enable full application of the printing form for all printing types.

Introduction

A contemporary graphic product is based on the end user requirements and this means that it must be individualized. Digital printing stresses its advantage as to the possibility of individualized printing. Research work described in this paper has given algorithms of individual mutant screening of each image element in a specific manner. The advantages are in the application that must have a higher level of individuality, the quality of not being able to be repeated and dependence on the information contents that the graphics and graphic design carry. In case of reproducing a color image the possibility is stressed to design programmed joining of different color channels with choise of screen element. As there is a growing trend to mix process and spot inks in the same graphic page, the multiplied joining of screen element shapes opens a new area of graphic application. It is proposed to use positive and negative deformation of SE from the same set in the same position for different color channels.

It has been determined that the numerical parameter values in the algorithm given as a classical mathematical formula converted into PostScript are different from the PostScript executive formula. This has opened the area for studying the screen element generating during bitmap forming in the printed form. The paper gives algorithms that rip the image and its image elements through new mutant screen elements in order to enable full application of the printing form for all printing types.

Screen element models with continuous mutation development

Continuous mutation development is applied on three screen element models: ellipse, ring, rhombus. Their application can be in different graphic design variants. Figure 1 shows one designer execution of using mutant screen elements with central positioning.

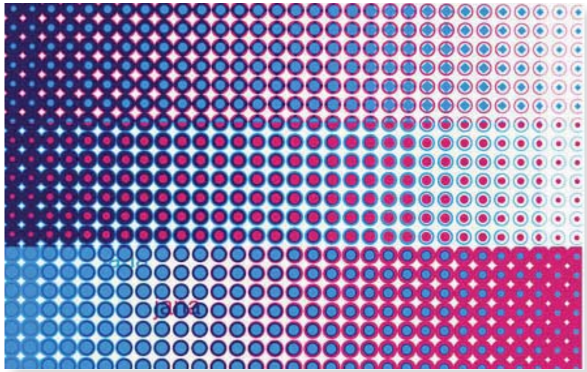

Figure 1: Center positioning of screen elements

Relations that describe the SE shape have limitations that may be seen in the 3D interpretation. The rastering cell is defined within the space x:-1, 1 ; y:-1, 1 ; z:0, 1. The greatest number of slowdowns in researching new SE is in respect to coordinate z. The first correction must be made through the 3D display. The screen cell covering

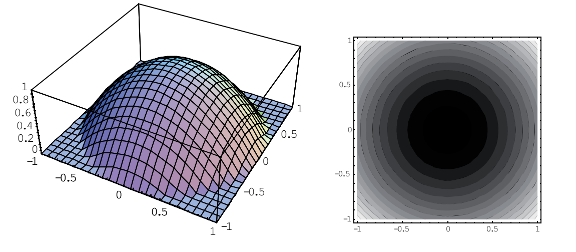

Figure 2: 3D and 2D model of circle SE

range has been researched with the Mathematica program where mathematical models are tested and the subsequently derived relations are then translated into PostScript.

The z=f(x,y) function is the mathematical interpretation of algorithm growth in the screen area that in fact determines SE. The screen area contains as many (x,y) points n as is the square of the printout resolution R and screen ruling L ratio:

$$n = \frac{R^2}{L^2}$$

There are 36 (x,y) points for 300 dpi resolution and 50 lpi screen ruling. When there is a case of much higher ratios such as with resolutions for film or offset plate exposure where the resolution might have a value of 2400 dpi, with the typical screen ruling of 150 lpi, the number of necessary screen cell dots is 256.

The screen element representing a complete circle is given with the relation:

$$z = 1 - (x^2 + y^2)$$

Figure 2 shows 3D and 2D models of the circle SE. This is the method for investigating the growth factor z for all screen elements in this paper.

The SE integrity for all grey levels has been achieved on basis of the growth sequence procedure taking care that each image element that has once been «turned on» for the grey level j must remain turned on for all grey levels k > j. This is checked in the 2D model of the SE display.

Ellipse shape SE development

The ellipse shape may be completed on basis of a circular shape with coefficient non-symmetry and with variables x or y. Figure 3 shows an ellipse shape SE model defined with two different z functions.

Such a shape must not be directly transformed into PostScript function. It is necessary to check the horizontal and vertical parameters in deformations so that no interruptions occur in carrying out the screen element image creating in the PostScript language image function. Interruptions in carrying out the SE for the targeted grey level most often occur due to poor protection of the mathematical co-domain z that must be inside the range of [0, 1]. PostScript is a stack oriented language. For each point in the screen area the PostScript interpreter places an x and y coordinate on the operative stack and calculates z=f(x,y). The dots with greater z coefficient will be shown on the lighter grey levels and vice versa.

Due to this in cases of both the ellipse and the circle the basic equation is subtracted from 1 in order to comply with the interval [0, 1]. In both the equations x and y are squared and added factorized. Due to this it is not necessary to

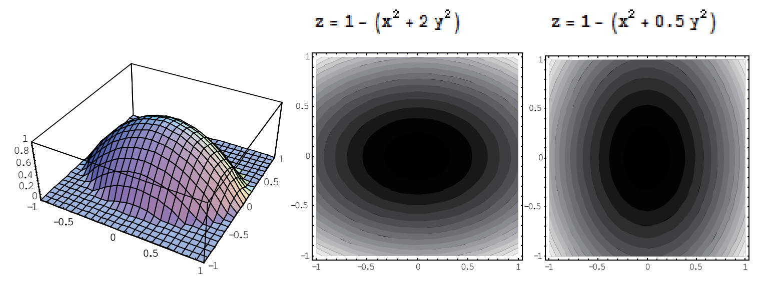

Figure 3: Ellipse shape SE with parameters 2 and 0.5

worry about the lower limit point of the [0, 1] interval for such types.

In experimental creating of the ellipse SE it is sufficient to parameter one component coordinate. Figure 3 shows 2D results of the y^2 component parametrization. If we should parametrize only component x^2 we would get results rotated by 90^0. For the screening process it is the same thing because SE is composed in the matrix of a defined frequency with a determined screen ruling in components of two dimensions.

The same applies to ring deformation with the parameter of either the horizontal or vertical coordinates. In Figure 5 SE is illustrated with concentric rings within the screen cell with ellipse shape deformation.

Ring shape SE development

Relations for the ring shape basically use the circle equation inside the trigonometric form (Figure 4). The factor in front of the radix is the parameter with which the creation of the concentric ring number in SE is regulated. It must be higher than 3 so as to create at least one whole ring.

The same applies to ring deformation with the parameter of either the horizontal or vertical coordinates. In Figure 5 SE is illustrated with concentric rings within the screen cell with ellipse shape deformation.

The deformation parameter with the x^2 component is subsequently subject to random value that will result in the experience of many new screen shapes within the same graphic reproduction. Although there is experimenting here with major deformations, PostScript accepts them. The y axis has two ring periods inside the cell, while the x axis repeats the ring four times. The last ring is flattened inside the screen cell, and in graphic reproduction this part will look like a straight line. Figures 6 and 7 show with the help of parameter 0.1 the positive and negative deformations of the ring shape SE with a major deformation. There is no subtraction from 1 in the negative deformation.

Development of the rhombus SE

In its variants the rhombus shape SE is square and rhomboid form. It is characteristic for the set absolute values in order to make use of the total definition area. The basic 2D and 3D model is shown in figure 8.

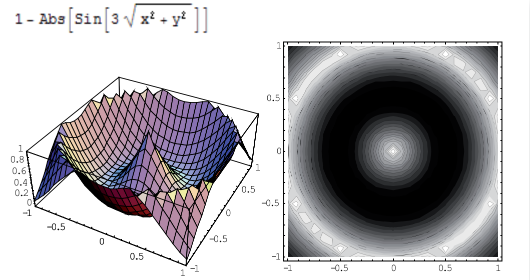

Figure 4:: The basic ring shape SE

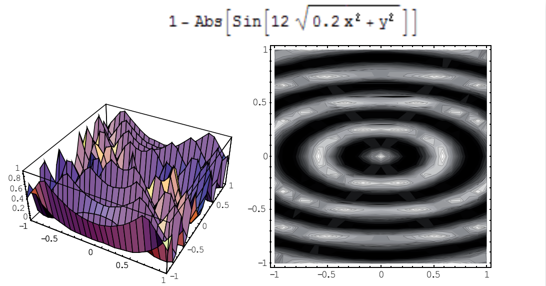

Figure 5: SE with ellipse shape deformation of concentric rings

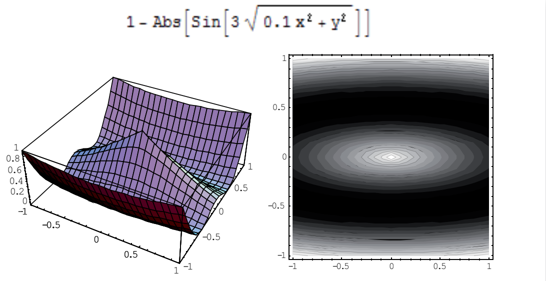

Figure 6: Positive deformation of the ring SE

Experiments have been made for many changes and no-symmetries (Figure 9). The paper presents this screen shape as a connection for comparison with new screens that have been researched in the behavior area of their outline and covering range in the reproduction process.

Executive PostScript screen elements

At the moment of fill, stroke, show and image commands the PostScript command already knows the priority of dot switch on in the screen cell for all grey levels (screening process). PostScript screen shape relations used in the practical part of the paper are shown in Figure 10.

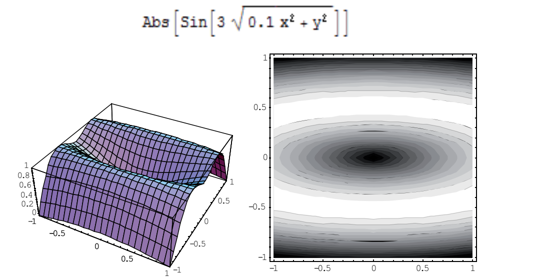

Figure 7: Negative deformation of the ring SE

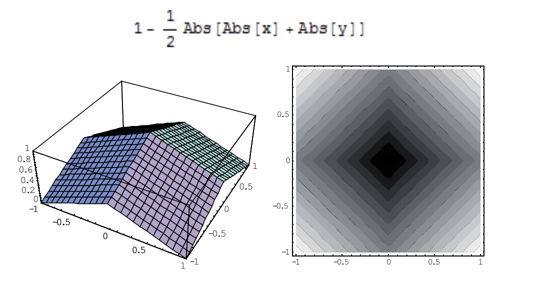

Figure 8: Figure 8 rhombus SE

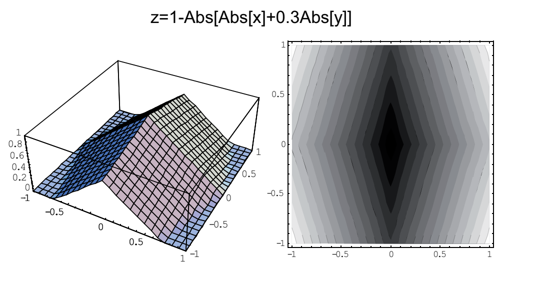

Figure 9: Deformation of the rhombus SE

```
/elipsa {koryH mul dup mul exch koryV mul
dup mul add 1 exch sub} bind def
/romb {koryH mul abs exch abs add 2 div 1
exch sub} bind def
/ring {koryH mul dup mul exch dup mul add
1 mul sqrt 120 mul sin abs} bind def
/ring3 {koryH mul dup mul exch dup mul
add 1 mul sqrt 360 mul sin abs} bind def
```

Figure 10: PostScript SE relations

```
/koryH 1 def /koryV 0.6
def /RE 0 def
/Ros [ {ring} {elipsa}
{romb} {ring3} ] def
4 {gsave /koryH 1 def
/koryV 0.6 def
40 40 translate
14{ /lin 5 def /kut 90
def
lin kut Ros RE  get  bind
setscreen
1 3 4 [1 20 div 0 0 1 20
div  0 1 ] {<8>} image
20 0 translate
/koryH koryH 0.06 sub def
/koryV koryV 0.02 add def
} repeat
grestore /RE RE 1 add def
0 70 translate
} repeat
/Helvetica findfont 14
scalefont setfont 0
setgray
100 -55 moveto(jana) show
showpage
```

Figure 11: Flattening of screen element shape with „8" hex lightness (50% grey level)

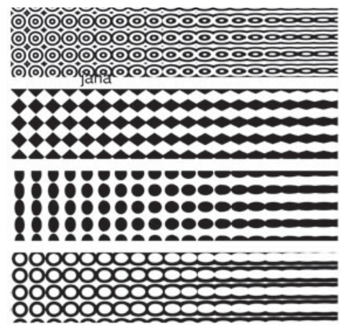

Figure 12: Design with mutant modulation screen elements

Figure 11 shows the PostScript program with which the design with mutant modulation screen elements was carried out (Figure 12) that uses the upper SE relations. The algorithm mutates screen elements by flattening (deforming) for one grey level by 50%. In the Ros array z function calls are defined for determined screen shapes.

Horizontal deformation begins with the value koryH=1. This value is gradually decreased by the coefficient 0.06 in each following SE. The circle/ellipse screen shape has two internal deformation variables: koryH and koryV. Vertical deformation begins with the deformation level; the ellipse becomes a circle shape and proceeds towards flattening. Coding of the grey level of each pixel is preset at 4 bits and with the <8> hexadecimal the grey tone is preset at 50%. The image command draws 3 vertical pixels each time with a certain set combination of SE and deformation, and then a new circle of the repeat loop is entered. Thus the pixel threesomes are printed out 14 times with different screen element mutations.

Screen elements with double circumference in stochastic application

The richness of stochastic screening is based on implementation of individual solutions in parameters with which screen ruling, angle and screen shape types are chosen. Areas have been researched where stochastic has been introduced into the relation describing the screen element. At the moment of activating relations describing the SE it is necessary to have two scalars on top of the stack. They will determine SE building depending on the set covering range from the screen cell, depending on the screen ruling and screen angle. The two scalars can be activated in order to change their values in a pseudo-random manner, and all this before starting to calculate the preset SE shape.

In this sense experiments have been carried out for all the SE covered by this paper. The width borders for the random numbers are researched separately in order as to not be the reason for interruption in the course of carrying out screen preparation activities in CTP or direct execution in digital printing. These units do not report about the reason for stoppage in the process of determining screen element (ripping) characteristics. Figure 13 shows the graphic execution in a color that uses the double-ring SE with a stochastic choice of value for horizontal variables on top of the stack.

The double-ring SE with two exterior and two interior shells inside the screen cell is given in the relation:

```
/ring3 {koryH mul dup mul exch dup mul add 1
mul sqrt 360 mul sin abs} bind def /korH 0.7 rnd
mul 0.2 add def
```

The scalar koryH is chosen pseudo-randomly. The congruent choice may use the standard command rnd offered by PostScript itself or one's own algorithm. In such a case the secret of the used congruency parameters will fully provide security of the executed graphics. Using the initial seed values provides individualization possibilities. This value will give another internal solution for screen shape, screen ruling and screen element mutation.

Figure 13: Positive deformation of the ring SE

A step has been taken to correct the top stack value above variabl korH in such a manner that each time the SE relation is called, its value is corrected as a random value in the range from 0.2 to 0.9. This affects in a major way the altering of the double-ring model, and this is shown in Figures 14 and 15 (as a detail 12 pixels from the image «grape» center in Image 13) for each color separately in the CMYK system. Figure 16 shows the final CMYK design of that detail.

Figure 14: Cyan and magenta with double-ring SE and stochastic choice of the first scalar

Figure 15: Yellow and black with double-ring SE and stochastic choice of the first scalar

Figure 16: Double ring SE in all channels with a stochastic parameter in determining the elongation and compaction of the ring shape

The screen cell size changes depending on screen ruling

```
/L {5 10 rn mul add } def %random number from
5 to 15
```

Pixels with a low gray level have been designed so that the ring becomes an almost flat line (the korH variable value is minimum), and some pixels seem to contain several concentrated rings. The influence of the stochastic component on the double ring shape may lead us to the conclusion that this includes many different SE mathematical shapes. Although it was obtained with only one basic shape, the impression of the screen element shape richness is reached owing to the stochastic parameter description that determines screening and the SE itself.

Conclusion

The continuous mutation development with three screen element models has been shown in this paper, as well as their application in graphic design and security printing variants. For each SE model a mathematical z=f(x,y) growth function has been defined and the corresponding 2D and 3D display. In this manner the model for developing ellipse, ring and rhombus SE shapes has been shown. For each of these models mathematical deformation models have been defined, and this is also the algorithm basis for SE shape mutating. The SE mutation algorithm has been derived with the help of the displayed PostScript program and uses mathematically defined and tested SE models.

The area for introducing stochastics inside the very relation defining the screen shape has been researched. Parameters of mathematical function f(x,y) become pseudo-random numbers. An example is shown for using the deformation of the double ring model for the CMYK color system. A stochastic element is set in it for determining the elongation and compaction of the ring shape. The impression has been achieved of various screen element shape abundance, although it has been obtained with only one basic form. The paper gives algorithms that rip the image and its image elements through new mutant screen elements in order to enable full application of the printing form for all printing types.

Reference

[1] J. Žiljak, I. Žiljak, Elaboration of the Design of the Raster Elements on Securities, Procedings of the 6th international Design conference, Editor D. Marjanović, Dubrovnik, 2002.
[2] J. Žiljak, V. Vančina, D. Agić, I. Žiljak, K.Pap:"New screening elements in multi-colour printing for special purposes „, 30th International Research Conference of IARIGAI, Dubrovnik, 2003,
[3] I. Žiljak, J. Žiljak Vujić, Elaboration of design of screening elements, 8th International Design Conference Design 2004.
[4] Žiljak, Ivana; Pap, Klaudio; Agić, Darko:" Behaviour of Some Custom Programmed Screening Elements in Various Printing Systems", 32nd International Iarigai Research Conference, Haikko Minor, Porvoo, Finland2001



Jana Ž. Vujić, PhD
Polytehnic of Zagreb, I. Lučića 5, HR-10000 Zagreb, Croatia; janazv@zg.tvz.hr

Klaudio Pap, PhD
University of Zagreb, Faculty of Graphic Arts, Getaldiceva 2, HR-10000 Zagreb, Croatia; klaudio.pap@zg.t-com.hr

Ivana Žiljak, PhD
University of Zagreb, Faculty of Graphic Arts, Getaldiceva 2, HR-10000 Zagreb, Croatia; ivana.ziljak@vip.hr