Generating Textures Algorithm using Causal Modulation of Shapes.

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***Abstract*-In this paper is proposed one algorithm for generating synthetic texture based on modulation of shapes, that covers the two-dimensional surface. The modulation gives as a result a different textures, composed by two-dimensioned regions. Using different modulation finctions it is possible to create different pattern images. Additional parameters are the color of lines and fill color of rectangular element.**

***Keywords*: texture generation, shapes modulation, covering of surface**

I. INTRODUCTION

Pattern images (textures) are useful in computer graphics, especially in object's synthesis. They give realistic appearance of artificial generated surfaces. Digital textures can be obtained using different sources, but usually obtained texture hasn't needed dimensions and shape. If we use a simple repetition of given piece of textured surface, we will obtain unacceptable defects - well visible transitions and. repetitions. Better results give methods, which generate textures using direct synthesis by computation. These methods can be separated in two groups

Methods that create textures, using given pattern.
Methods, that create textures, using given casual or determined function.

In this paper is proposed one algorithm for generating synthetic textures, based on modulation of shapes, that covers the two-dimensional surface. Method is development of offered in [1] method for texture generation based on modulation of apexes of polygons, that covers given two-dimensional surface.

II. COVERING OF TWO-DIMENSIONAL SURFACE BY POLYGONS

As it is known in mathematics, full covering of plain by regular polygons is possible only for triangles, rectangles, pentagons and hexagons. Many full coverings by different shapes are known, including shapes of birds, animals and others. All these coverings, regardless of used shapes, can be classified as a generation of some determined function.

As a result this generation gives co-ordinates of polygon's apexes, which covers the surface.

Textures, created by determined function look like artificial, while the others, created, using casual functions, look more realistic, like obtained from existing object's surface.

III. PROBLEM DESCRIPTION

Many of known algorithms for casual texture generation perform arrange of pixels from given pattern to larger surface or use some spectral analysis of pattern and generate texture having given dimensions and similar spectrum. Textures, generated in this way, haven't distinguished objects despite of they have look like similar.

On the other hand, can be found many real textures that have "grain" surface, including objects with casual variation of dimensions or other parameters. One of the problems of texture generation is to discover algorithm that can obtain textures with "grain" surface and given variation of parameters.

IV. COVERING BY CASUAL SHAPES

Proposed algorithm use described in [1] algorithm for covering of two-dimensioned surface with casual polygons. This algorithm uses a determined function for covering of two-dimensional surface by given regular polygons and modulation of polygon's parameters by casual function. Generated function (GF) gives co-ordinates of polygon's apexs. Co-ordinates of apexes will look as follows:

$$\begin{cases} x(n) = F_x(n) \\ y(n) = F_y(n) \end{cases} \quad (1)$$

where n is the number of current point
Type of functions $F_x(n)$ и $F_y(n)$ and scheme of apexes connections determine the polygons, that will be obtained.. For description of scheme for apexes connections it is useful to describe apexes by two decartian co-ordinates n1 (as x co-ordinate) and n2 (as y co-ordinate , $n1 \in [0,N1]$, $n2 \in [0,N2]$., which are related with n as follows:

$$n = n1 + N1 * n2 \quad (2)$$

where N1 и N2 are dimensions (in number of points) of

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rectangular area D, in which functions x(n1,n2) и y(n1,n2) are defined.

In example, the covering by rectangles with dimensions A*B can be obtained using functions x(n1,n2) , y(n1,n2) and connections L1, L2, L3 и L4, given as follows.

$$\begin{aligned} x(n1,n2) &= A*n1 \\ y(n1,n2) &= B*n2 \end{aligned} \tag{3}$$

$$\begin{aligned} &L1:(n1,n2)-(n1+1,n2) \\ &L2:(n1+1,n2)-(n1+1,n2+1) \\ &L3:(n1+1,n2+1)-(n1,n2+1) \\ &L4:(n1,n2+1)-(n1,n2) \end{aligned} \tag{4}$$

In [1] was given others schemes for apexes connections that produced others coverings by regular polygons

V MODULATION OF POLYGONS

Modulation is non-linear transformation of signal that changes some parameter of given signal in according of modification of other signal, named modulator [3]. In our case we consider functions Fx(n1,n2) и Fy(n1,n2), that describes co-ordinates of polygon's apexes, as digital signals. As a modulators, that gives modification of co-ordinates of polygon's apexes we will use functions Mx(n1,n2) и My(n1,n2) as follows:

$$\begin{cases} x(n1,n2) = Mx(n1,n2) + Fx(n1,n2) \\ y(n1,n2) = My(n1,n2) + Fy(n1,n2) \end{cases} \tag{5}$$

For prevent cut across borderlines of polygons, the deviation of apexes co-ordinates can be not greater then a half of initial dimension of corresponding border line. Using casual function as a modulator will give as a result covering by polygons, which dimensions are functions of casual variable (fig. 1)

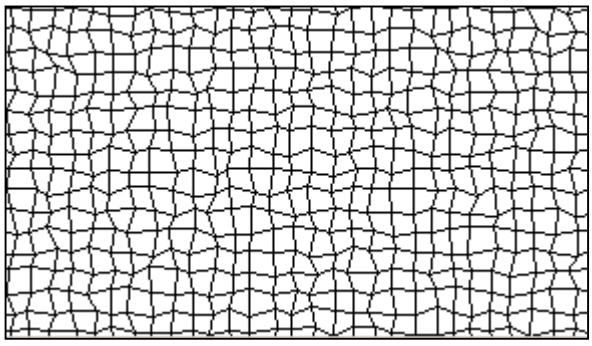


Fig. 1 Covering by polygons using casual function as a modulator

VI. SMOOTHING OF CONTOURS USING LF FILTER

Textures, composed by polygons look like artificial created. For obtain more realistic behavior of texture it is useful to smooth the contours of shapes. Smoothing can be obtained, using Low frequency (LF) filter as the apexes of polygons corresponds to the height frequencies in spectrum, while the smooth curves corresponds to the low frequencies in spectrum of contour functions n1(n) и n2(n).

As it is known, the calculation of output of digital filter can be given as [2].

$$y(n) = \sum_{m=-\infty}^{\infty} h(m).x(n-m) \tag{6}$$

where:
h(m) is impulse response of digital filter.
x(n) - input signal
y(n) - output signal
In this case it is useful to use non-recursive

filter, which impulse function has limited length, because it's transitional process has limited length too. This will make the smoothed contour independent from start point of smoothing. So, for offered method smoothed contour functions $n1_s(n)$ и $n2_s(n)$ will be obtained using non-recursive filter as follows:

$$\begin{cases} n1_s(n) = \sum_{m=-N/2}^{N/2} h(m).n1(n-m) \\ n2_s(n) = \sum_{m=-N/2}^{N/2} h(m).n2(n-m) \end{cases} \tag{7}$$

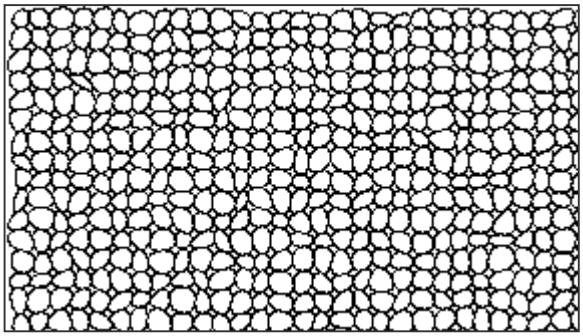
where:
n1(n) and n2(n) are contour functions
n1s(n) и n2s(n) are contour functions, obtained after smoothing
h(n) is impulse response of filters

As LF filter can be applied simple average filter, which length N of impulse response can be selected by operator. Because the value of N can't be too big (less then full length of contour) can't be found big difference between simple average filter and better filters, using known window functions like Haming's or Kaiser's functions. Smoothing of contours, using linear filters ids described in [5].

VII. RESULTS.

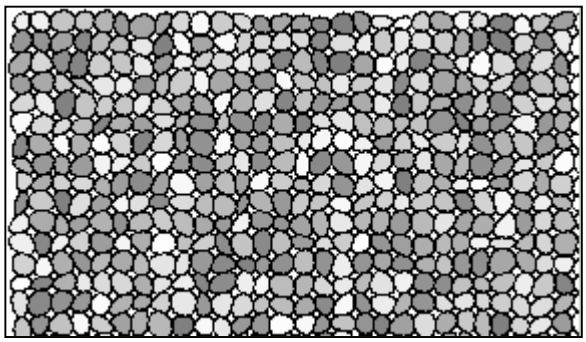
Described above algorithm has been used to create a program, that generate textures , giving possibility to select the parameters of created image – line and background colors and initial shape's dimensions. On fig. 2 is shown

one result of execution of this program using casual function as modulator. And smoothing using average window functions dimension, having dimension of 41 points.

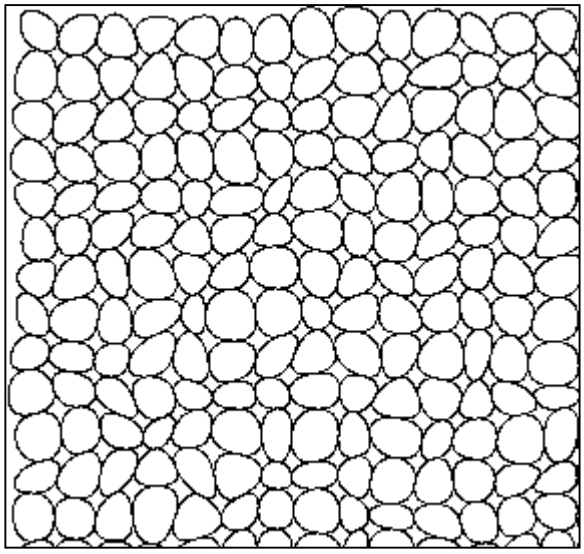


Фиг. 2 Texture, obtained after smoothing of contours.

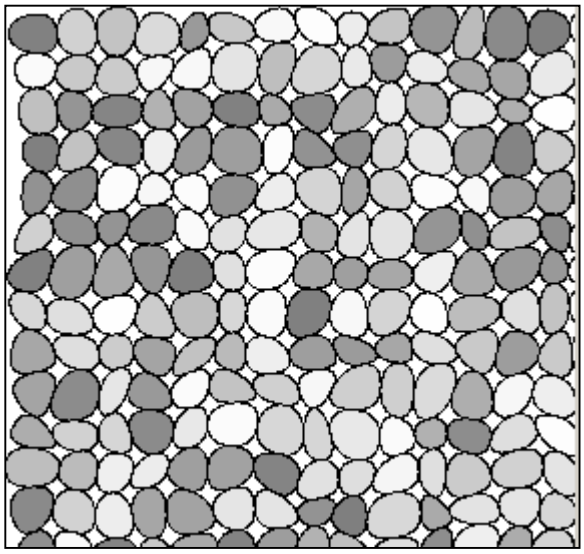
Different textures can be obtained after casual modulation of other parameters. On fig. 3 you can see the same texture after casual modulation of shape's colors.



Фиг. 3 Texture, obtained from previous, using casual modulation of shape's colors.



Фиг. 4 Texture with bigger initial dimension of shapes



Фиг. 5 Texture, obtained from previous, using casual modulation of shape's colors.

VIII. Conclusion

The proposed algorithm for texture generation is based on modulation of apexes of polygons using a casual function and smoothing of shapes using LF digital filter. The next development of this algorithm can be generating of textures using randomly ordered different shapes and next modulation of parameters of obtained texture using casual function. This will give possibility to generate many different realistic textures.

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