Determination of Characteristics Discrete Transfiguration for Synthesized Raster Elements of Non-regular Structure

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Abstract. The characteristics of the discrete raster transformation for the synthesized elements of non-regular structure have been determined and constructed in this article. Besides, the simulation model of discrete screening has been created with the help of the Simulink graphical programming environment. The dependence of the number of levels of the area of raster elements on the dimension of cells for typical values of the relative area is determined. It is established that the growth of the area of the raster element depends on the size of the cell. Moreover, a new algorithm for forming a raster matrix in which the management of the rasterization process carries out by sequentially adding one trace element with the size of 1×1 discrete area units is proposed and researched in this paper. It is experimental found that the rasterization characteristic for the proposed algorithm of forming the raster matrix is linear. Doubtless, it is an essential advantage of the proposed method.

Keywords: raster characteristic, raster element, discrete area units, discrete reproduction, screening, stochastic screening.

1 Introduction

The image reproduction and print quality are determined by a huge number of factors and one out of the crucial factor is the screening process in plate making [1]. To put it another way, the screening process might have an injurious impact on reproduction quality. Screening (rasterization) is the technique that is used in printing to simulate tones and

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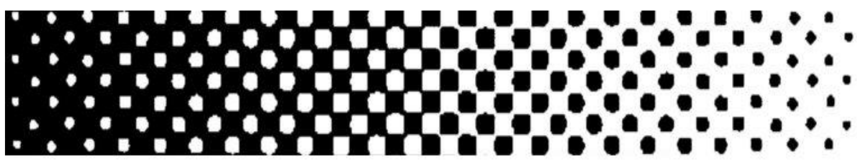
halftone [2] or continuous-tone images such as photographs using dots [3]. Polygraphic raster transformation has some peculiarities, and the first one out of them is that the discretization is carried out by changing the geometric dimensions of the elements. Furthermore, the area of the raster elements which are located in the raster cell is the carrier of information in this case. Also, it is to say that, this raster grid corresponds to the tone of the image [4].

The new raster structures such as Amplitude Modulated (AM screening, or autotypical raster Fig. 1, a), Frequency Modulated (FM screening, Fig. 1, b) [5, 6] and Hybrid (AM+FM) were created at the end of the twentieth century. For autotypical structures is characteristic that the tone values are made by the size of the raster dots: the larger the dot, the darker the tonality. While in FR raster the size of the raster dots is constant but their frequency is variable. Both of them have some pros and cons. Amplitude Modulated raster has better properties in mid-tones while Frequency Modulated raster is able to make a wider gamma rather than AM [7, 8, 9].

On the whole, it doesn't matter which kind of raster technology to choose, because each out of them must achieve the following goals [10]:

- make the image appear as close to continuous tone as possible;
- support appropriate plate printability;
- eliminate as much of the inherent noise and moiré as possible [10].


a)


b)

Fig. 1. Example of AM and FM screening.

Besides, raster elements with non-regular structure, stochastic [5, 11] and pseudo-stochastic screening were implemented. At the same time, it is the specificity of the discrete formation of raster elements of the necessary shape and structure that determines the problem of choosing traditional and new methods of rasterization in CtP (Computer to Plate) systems.

2 Review and problem statement

The shape of the synthesized raster elements should ensure fully reproduction of their area during plate exposures, and transfer from the printing plate to the imprint. The setpoint value of the area during the discrete formation of the raster element may have a different shape [12], which largely depends on the accuracy of the plate exposure, the manufacturing of the printing plate and its reproduction on a bitmap imprint. Classical screening methods are shown in the sources [5, 6, 10]. There the physics of formation of bitmap images is described as well as their basic parameters and results of experimental studies carried out in various tests based on which the quality of printed reproduction of raster images is assessed. In particular, in some articles [6, 13] the problem of mathematical description, synthesis and creating spatial reproduction schemes of discrete formation of a square raster element of irregular structure is considered. The article [7] describes the image superresolution method with the aggregate divergence matrix. A new screening method based on the new form of screening element in improving printing quality was considered in the paper [14]. Besides, paper [12] represents the influence of raster elements shape on the printing quality. However, the question remains of determining the characteristics of a discrete raster transform that needs further investigation.

The aim of the article is to define, construct and analyze the characteristics of a discrete polygraphic raster transformation for non-regular structure elements.

3 Development of an algorithm for forming the raster matrix

One out of the significant stages of pre-printing preparation of images is the screening process, which consists of converting tone images into a microstrip, in the form of a two-dimensional array of dots or elements of another form, where the information carrier is the area of the raster element. According to the method of forming the area of the printing element is distinguished: continuous rasterization, which is conventionally called analog, and digital screening - screening with their discrete variable. It is found that in classical analog screening, the management of the rasterization process is carried out by changing the geometric dimensions, so as a result, the areas of the raster element depend on its shape. For instance, the area of a round element $S_K = \pi R^2$ and square – $S_K = a^2$. Thus, the characteristic of the rasterization process which describes the dependence of the raster element area on its geometric dimensions is nonlinear. Whereas a discrete raster transformation is inherently a discrete simulation of continuous rasterization, moreover it's also nonlinear, which is considered to be a flaw.

In order to carry out the synthesis of discrete raster transfiguration of different shapes elements during their formation by a sequence of rows of microstrips we accept the following assumptions:

- the polygraphic rasterization is a two-dimensional spatial transformation;
- the exposure of the raster element carries out by a flowing laser beam of a given diameter in the form of a sequence of rows in a raster cell of a given size and contains an integer number of rows;
- the element is placed in the center of the raster cell.

The element of a given shape is the result of raster transformation while the synthesis of raster transformation is reduced to determining the element area.

In the proposed algorithm of forming the matrix of rasterization, the control of the screening process is carried out by sequentially adding one microelement with a size of 1 × 1 discrete area units (dau). If the raster element has a non-regular structure, then the area of the raster element is described by expression (1):

$$S^* = \sum_{i=1}^{n} \sum_{j=1}^{m} w_i dau. \tag{1}$$

Therefore, the area of the raster element of the non-regular structure which is worked out according to the proposed algorithm, based on the raster matrix, will be determined by the sum of rows and will be equal to the number of microelements from which the wines are composed. Besides, the area of the raster element of the non-regular structure doesn't depend on its shape. Under those conditions, the rasterization characteristic for the proposed algorithm of forming the rastering matrix, which describes the dependence of the element area on the control of the screening process, is determined by the number of trace elements located in the cell of a given dimension, and will be linear, which is an advantage of the suggested algorithm.

3.1 Creation of the discrete rasterization characteristics

As an instance, to clearly show the graduation characteristics (Fig. 2.), we were calculated and constructed the characteristics of discrete rasterization for the small size of the raster cell (4 × 4 and 5 × 5) in accordance with the proposed algorithm.

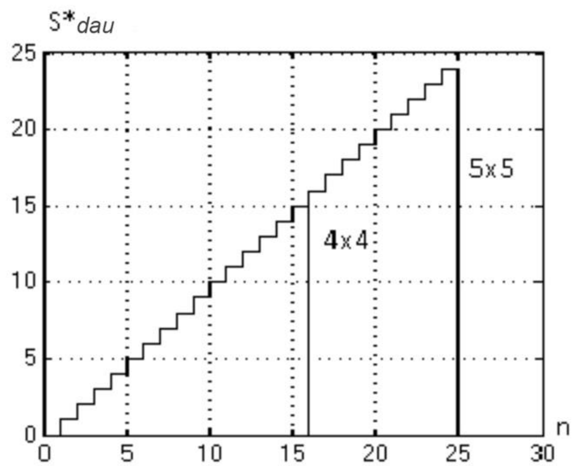


Fig. 2. Characteristics of discrete rasterization for small size raster cells.

As we can observe from the figure 2., the rasterization characteristics are linearly stepped and presented in absolute discrete units of area. The magnitude of one degree is constant over the entire screening interval and has a value of 1 *dau*. As the number of microelements in the raster cell rises, the characteristics gradually increase to 16 and 25 *dau*, respectively.

Besides, in the same way, the characteristics of discrete rasterization have been calculated and constructed for raster elements with the non-regular structure formed according to the proposed algorithm of the raster matrix for raster cells with dimensions 8 × 8, 12 × 12, 16 × 16. Figure 2 shows the characteristics of discrete rasterization.

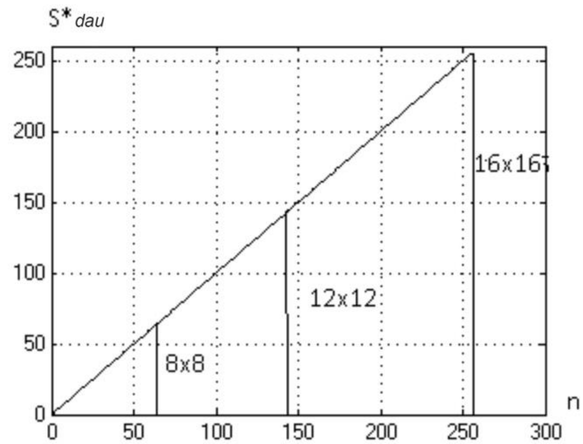


Fig. 3. Characteristics of discrete rasterization for high dimension raster cells.

Similarly to the previous case, the rasterization characteristics are linearly stepped, and have a magnitude degree - 1 *dau*. However, if the size of the cells is large then the pitch will become less inconspicuous. As the number of microelement in the raster cell increases, the characteristics gradually increase, and the value of their area goes up to 64, 144 and 256 *dau*. The complete results of the simulation are given in Table. 1.

3.2 Development of a simulation model of discrete rasterization

For the sake of simplicity and convenience of comparative analysis, we will replace the absolute value of the area of the raster element with the relative area in percentage, which is more used to the printing industry:

$$S^*\% = \frac{S^* dau}{S_K dau}\,100\% \quad , \qquad (2)$$

where S_K – the area of the raster cell which is given in discrete units of area, S^* – the sequence of discrete values of areas which is also given in discrete units of area.

If in expression (2) linearly, discretely change the sequence of areas according to the algorithm of forming raster elements on a raster matrix, then one can calculate and construct a raster characteristic for the elements of the non-regular structure. We will apply object-oriented programming in the Simulink package to solve this problem. For this purpose, a structural diagram of a simulation model of discrete raster transformation (Fig. 4) which is consists of functional blocks of the Simulink library was developed on the basis of expression (2).

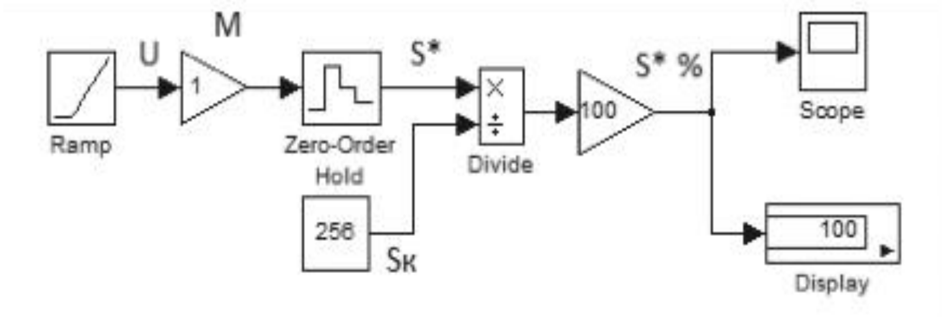


Fig. 4. Structural diagram of a simulated model of discrete rasterization.

The Ramp block generates a continuous linearly increasing signal that simulates a continuous linear tone scale which is scaled by the M block. The discretization block "Zero — Order Hold", with a given value of discretization degree of 1 *dau*, converts the input signal to a sequence of discrete area values. The relative area of discrete rasterization is determined by the method of dividing the discrete relative units of the area by the area of raster cell in the Divide block. After multiplying by 100, we get the area of the raster elements as a percentage. The calculation results of the discrete rasterization are visualized by the Scope block in the form of rasterization characteristics. The indications block "Display" shows the numerical values of the characteristic.

The main purpose of the simulation was to construct a characteristic of discrete rasterization for raster elements with non-regular structure, which are formed according to the algorithm specified by the raster matrix.

For example, we denoted the dimension of cells 4 × 4 and 5 × 5 and then adjust the model parameters according to the specified dimensions. The results of the simulation in the form of characteristics of discrete rasterization in percentages are shown in Fig. 5.

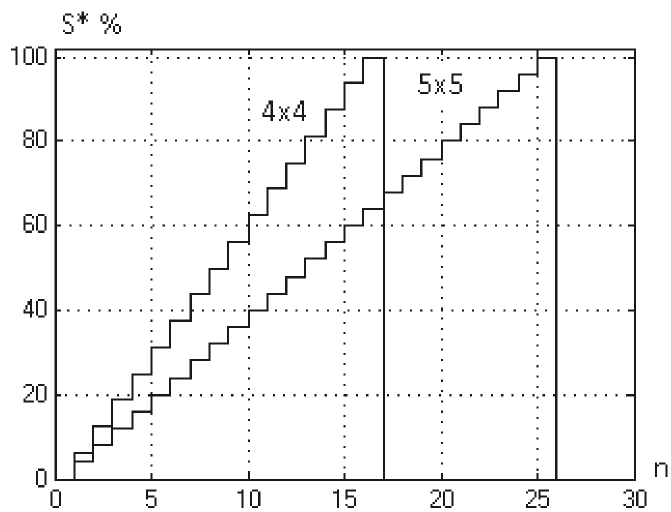


Fig. 5. Characteristics of discrete rasterization process for different cell dimensions.

The characteristics of discrete rasterization are linear. The characteristic of the rasterization of a cell of dimension 5 × 5 has 25 grades, while cells with 4 × 4 dimensions have 16 grades. Thus, the increment of the raster element area depends on the cell size. Decreasing the size of the cell increases the area gain, which causes the bitmap distortion during reproduction.

In the next example, we have chosen higher dimensions of the raster cells (8 × 8, 12 × 12, 16 × 16) and then set up the model parameters according to the specified dimensions. The results of the next simulation are presented in the form of discrete rasterization characteristics on Fig. 6.

It is apparent that the rasterization characteristics are linearly stepped as well as in the previous example. However, if the size of the cells is large then the pitch will become less inconspicuous on the figure. As the size of the raster cells increases, the rasterization characteristics shift to the right. Nevertheless, the percentage of the area goes up to 100% in this case.

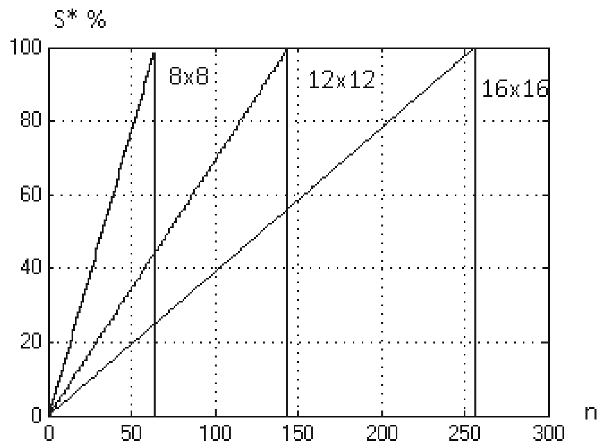


Fig. 6. Characteristics of discrete rasterization process for cells with higher dimensions.

The results of simulation modeling of the dependence of the number of levels of the area of the raster elements on the dimension of cells for typical values (10%, 25%, 50%, 75% and 90%) of the relative area are given in Table. 1.

Table 1. The dependence of the number of area levels of the raster elements on the dimension of the cells for standard values of the relative area.

The dimension of the raster cell	Levels of cells area	The area of raster elements (discrete area units) for typical values of relative area				
		90%	75%	50%	25%	10%
16×16	256	230	192	128	64	26
12×12	144	130	108	72	36	14
10×10	100	90	75	50	25	10
8×8	64	58	48	32	16	6
6×6	36	32	27	18	9	3

Based on table 1 we can observe how the area of raster elements for typical values of relative area changes. So, the area of the raster elements for the dimension of the raster cell 6x6 varies from 3 to 32 *dau*, while for 12x12 from 26 to 236 *dau*.

4 Conclusion

If compare fig. 3 and fig. 6 we can conclude that the rasterization characteristics which were constructed in absolute units of area and in relative units have a different appearance, thus more precisely characterize the process of discrete rasterization. According to the results which are presented in the table. 1, we can make conclude that for the given typical values of the relative area of the raster elements, the number of discrete elements depends linearly on the dimension of the raster cell. For instance, for a dimension of the 10×10 raster cell, the area of the raster elements fully corresponds to the typical relative area values in percent.

Therefore, the dependence of the relative area of the raster elements and the absolute values of the area on the number of elements is linear and doesn't depend on the raster cell dimension, which is an advantage of the proposed algorithm for forming elements of the raster matrix.

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