DEVELOPMENT OF TECHNIQUE FOR RECOGNITION OF THE COMPLEX SHAPE SIGNAL IMAGES

Oleg Choporov, Andrey Preobrazhenskiy, Eugen Ružický

Abstract:

With the help of digital image conversion, they create conditions for improving the perception of the image, the formation of a certain artistic image, the allocation of informative features. Image conversion is carried out by various methods, including optical, photochemical and digital methods. The latter are becoming increasingly common, as technical capabilities only grow from year to year. The purpose and objectives of this work: to analyze the main methods of image processing and recognition; to develop an effective algorithm for recognizing signal images; to develop a software product that conducts experiments to recognize complex waveforms. Information about the degree of similarity of the two signals is shown at their maximum coincidence and is determined by the behavior of the correlation integral (functional) at the extreme point, that is, the value of the integral and its derivatives. This functional is an energy characteristic, the value of which is determined by the brightness and area of the image visible through the standard. Its extremum is observed in cases where the standard is fully fit in the image, and the coincidence of their shape is not necessary. Therefore, this value characterizes the similarity of the image and the standard in form ambiguously. The absolute value of the second derivative of the correlation integral to the point of its extremum is preferable for estimating the similarity of the image and the standard in form. The dependence of the functionals on the degree of "blur"is presented. A necessary condition for the practical value of such recognition algorithm is the independence or weak dependence of the functional threshold value on the shape, area and contrast of the image. The table shows the values for some images with different area and contrast. as an indicator of the similarity of the image and the standard in form, it is advisable to use the module of the second derivative of the correlation integral normalized in contrast at the extreme point. First, the program receives the original image in bmp or jpeg format, and shows it to the user. The image is then muted according to the noise type selected by the user and the parameters set for the selected noise type, then displayed on the form. You can save an image, run an experiment (plot), define a shape, or noise the image again. To compare the capabilities of the algorithm under study and the human visual system according to the classification of "blurred" images, the images of simple geometric shapes are shown recognized by an automatic device implemented in the form of a software tool. The type of distortion that can be used: monochrome noise by Gauss, color noise by Gauss, spray, turn into mosaic, blur. The program compares the distorted image with each of the available reference figures, estimates the total standard deviation, and concludes what image is depicted, based on its minimum value.

Keywords:

Image cognition, algorithm, program

ACM Computing Classification System:

Computer vision, Human computer interaction, Information systems applications

Introduction

Currently, digital image conversion is widely used in measurement and applied television systems and broadcast television. With the help of digital image conversion, conditions are created to improve the perception of the image, the formation of a certain artistic image, the allocation of informative features (for example, in object recognition systems), etc. Conversion is carried out by various methods, which include optical, photochemical and digital methods [1, 2]. The latter are becoming increasingly common, as technical capabilities only grow from year to year. Despite the fact that other methods are a little passed the position, all these are of independent interest in communications technology, computer technology, medicine, the environment, the conversion of film images and other various fields.

A number of approaches to the study of images is based not only on the use of a priori data about the optical characteristics of the image, but also on the possibilities of implementing the analysis procedures. For example: the use of image analysis procedures to control chip patterns, in medicine and biology in the analysis of blood smears, etc.

Purpose and objectives of this work:

- To analyze the main methods of image processing and recognition;
- Develop an efficient algorithm for signal image recognition
- To develop a software product that conducts experiments to recognize complex waveforms.

1 Image recognition algorithm

The initial data for the classification of images of structural or physical features are the results of the measurement of the latter. The most informative stable characteristic of a simple image is its shape, as the color and brightness distribution of the image in real conditions are variable and are not always class features. Under the form in General, the external outline, external view, contours of the object. For a two-dimensional image, it is difficult to define the shape as a specific trajectory for each class of images in the form of a closed line in the relative coordinate system. Unlike video and radio signals, the form of which determines the noise immunity of reception, measurement accuracy, resolution and other frequency-energy factors, the form of images is essentially a visa-al code, which contains information about the name, purpose and other information about the object of observation.

Closed lines can have an infinite number of trajectories, which creates a significant redundancy in this encoding of information. Perhaps that is why, when perceiving contour images, the visual analyzer of the human brain easily completes the missing fragments of the form and perceives the set of contours as a complete image [3, 4].

The peculiarity of the classification feature is the impossibility of its evaluation, since the signal code, including the shape of the image, is not subject to measurement. To evaluate only the degree of conformity (similarity) with the same signal structure (the benchmark).

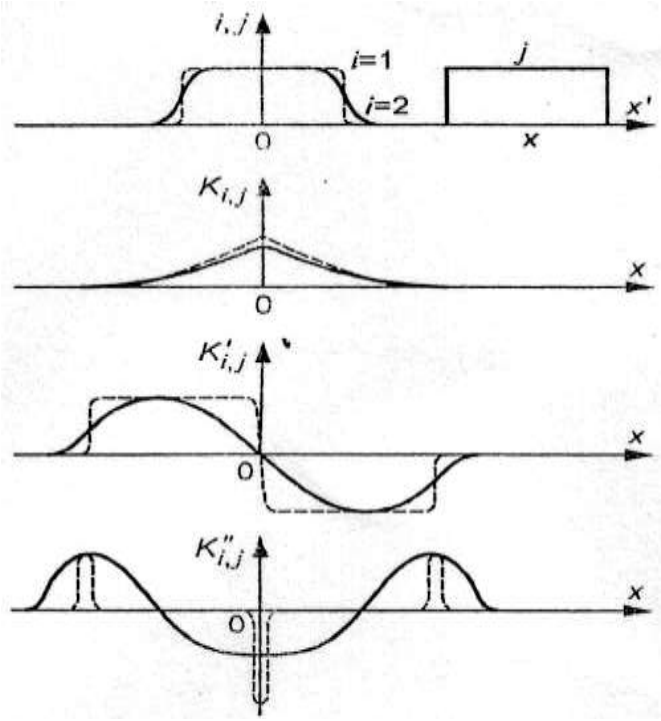


Fig.1. Definition of a parameter containing information on the similarity of the signal and the standard in form

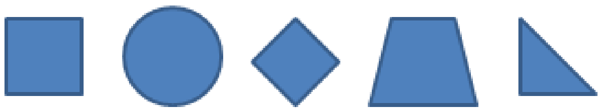


Fig.2. Geometric figures presented for recognition

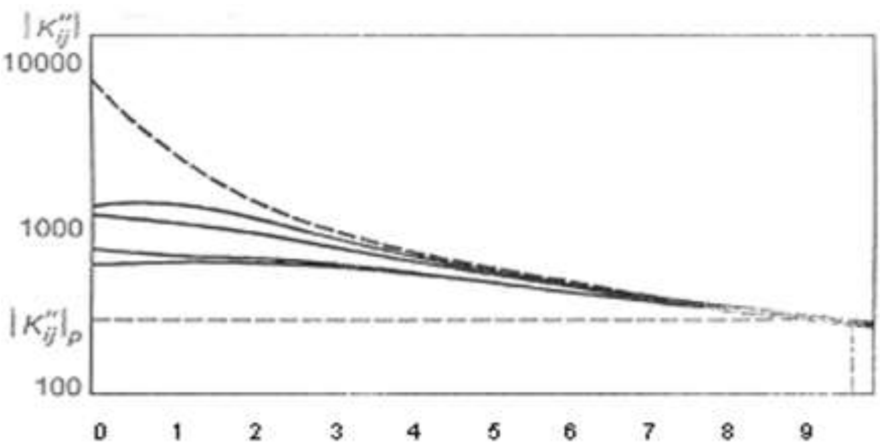


Fig.3. Dependence of the trapezoid similarity with the standards on the degree of its "Blur»

Presumably, the information about the degree of similarity between the two signals i(x, y) and j(x, y) appears at their maximum coincidence and is determined by the behavior of the correlation integral at the extreme point, i.e. the value of the integral (KI) and its derivatives (1)

$$Kij(x,y)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} i(x',y')\,j(x'-x,y'-y)\,dx'dy' \qquad (1)$$

To identify the parameter containing the required information, we analyze the dependence of these characteristics of the correlation integral on the distortion (change) of the image shape. To simplify the analysis, let's consider a one-dimensional signal passing through a low-pass filter.

Figure 1 shows two distorted rectangular pulses of different degrees i_1, j_2, the reference pulse *j*, their correlation integral K_{ij}, its first $K'ij$ and second $K''ij$ derivatives. It follows from figure 1 that the odd derivatives at the extreme point of the correlation integral are zero, and the even ones depend monotonically on the degree of "blur" of the momentum. Therefore, for comparative analysis it is advisable to allocate the values of the correlation integral and its second derivative at the extreme point.

Functional K_{ij}, it is an energy characteristic, the value of which is determined by the brightness and area visible through the standard image. Its extremum is observed in cases where the standard is fully fit in the image, and the coincidence of their shape is not necessary. Therefore, the value K_{ij} characterizes ambiguously the similarity of the image and the standard in form.

The second derivative of the correlation integral $K''ij$ essentially depends on the correspondence of the signal form, striving for the absolute value to infinity with perfect similarity (see Fig. 1).In this case, the change in the image area can not be compensated for its non-compliance with the standard form, since the value $|K''ij|$ decreases due to the formation of a flat portion of the top of the correlation integral.

Therefore, the absolute value of the second derivative of the correlation integral to the point of its extremum is preferable for estimating the similarity of the image and the standard in form.

We will analyze the peculiarities of using the functional $|K''ij|$ in recognition problems by the example of classification of the geometric shapes depicted in figure 2. Image ν of each figure with the help of a graphic editor Adobe Photoshop formed the standard of the file in the form of a file in the Windows BitMap format. In the course of research, the images were gradually distorted using the developed program (see below) and the similarity of the obtained images i with each of the standards j (2) was evaluated.

$$i(x,y)=\frac{1}{2\pi\delta^2}\int_{-\infty}^{\infty} v(x_1,y_1)e^{-0,5\frac{(x-x_1)^2+(y-y_1)^2}{\delta^2}}dx_1dy_1 \qquad (2)$$

In Fig. 3 we can see the dependence of the functionals $|K''ij|$ on the degree of "blurring" of the trapezoid is characterized by parameter σ. From figure 3 it can be seen that the similarity of a trapezoid with its own benchmark (dotted line) is dominant to the values of $\sigma \approx 9{,}4$ the pixels in which the dotted line and one or more solid lines, describing an image similar to nonproprietary standards intersect.

The corresponding intersection point of the functional value will be called the threshold ($\left|K^{"}ij\right|_p$). Further "blurring" of the image entails a decrease in its similarity with its own pattern in comparison with some of the improper patterns.

As shown in the figure. 3 the dependences are typical for all the geometric shapes under study, the classification of the presented image involves an assessment of its similarity with each of the standards, the choice of the largest functional $\left|K^{"}ij\right|$ and its comparison with a non-threshold. If the value of $\left|K^{"}ij\right|_{\max}$ is greater than the threshold shown, the image of the standard corresponding to this functional is considered, if it is equal to or less than the threshold, the recognition is rejected.

It is easy to show that the necessary condition for the practical value of such recognition algorithm is the independence or weak dependence of the functional threshold value $\left|K^{"}ij\right|$ on the shape, area and contrast of the image. Table 1 shows the values $\left|K^{"}ij\right|_p$ for some images with different areas of S and contrast, expressed in pixels and machine units, respectively. According to these data, the threshold $\left|K^{"}ij\right|_p$ is slightly dependent on the shape and area of the image [5, 6], but is proportional to the absolute value of its contrast. The normalization of the functional $\left|K^{"}ij\right|$ on image contrast allows to eliminate this dependence, as evidenced by the data in table 2.

Table 1-Functional thresholds $\left|K^{"}ij\right|$

Image	S	ΔB		
		50	-50	200
Square	625	99.5	99.5	398.1
	2500	108.	108.	435
	10000	112.6	112.6	450.6
Right triangle	625	99.9	99.9	399.8
	2500	98.7	98.7	394.9
	10000	96.3	96.3	385.2
Rhombus	625	92.7	92.7	370.7
	2500	111.3	111.3	445
	10000	110	110	439.9

Table 2-Threshold values of the contrast normalized functional image $\left|K^{"}ij\right|$

Image	S	ΔB		
		50	-50	200
Square	625	2.82	2.82	2.82
	2500	2.89	2.89	2.89
	10000	2.88	2.88	2.88
Right triangle	625	2.81	2.81	2.81
	2500	2.79	2.79	2.79
	10000	2.78	2.78	2.78
Rhombus	625	2.78	2.78	2.78
	2500	2.87	2.87	2.87
	10000	2.88	2.88	2.88

Thus, as an indicator of the similarity of the image and the standard in form, it is advisable to use the module of the second derivative of the correlation integral normalized in contrast at the extreme point.

For the convenience of further presentation, we denote: W_{ij} - the similarity index of the image i and the standard j; W_v -the threshold value of the indicator W_{ij} at $i = f(v)$, $j \in J$; J the set (bank) of patterns; W — the threshold for deciding on the compliance of the presented image i to a particular standard. With this in mind, the decision rule can be written as follows (3), where q is the image of the standard, in which the similarity index W_{ij} reaches its maximum value on the set of standards J.

$$\begin{cases} q = \arg\max(W_{ij}) \\ \quad j \in J \\ \quad v = q \\ \quad Wiq \leq W, \\ \quad v \notin J \end{cases} \tag{3}$$

The reliability of image recognition is determined by the value of the threshold W. to avoid incorrect classification, the threshold W must be equal to or greater than the maximum for the set of images V threshold W_v, where V is the set of images of objects of observation corresponding to the set of standards J.

$$W_{max} \geq_{v \notin V}^{max} (W_v) \tag{4}$$

In this case, the capabilities of the algorithm to recognize distorted images are somewhat reduced. Indeed, the majority of images v individual threshold recognition W_v will be less than the total threshold W, but when $W > Wig > W_v$ will be a refusal of recognition, although the image v can still be classified correctly.

When the W threshold is reduced, there is a possibility of incorrect recognition of images for which $W_v > W$,, but the degree of distortion at which these images can be correctly recognized increases. This condition (4) applies to all images [7, 8] if the W threshold is less than the minimum individual W_v threshold. If recognition rejection is not allowed, i.e. the image must be classified at any distortion degree, the W threshold is equal to zero.

First, the program receives the original image in bmp or jpeg format, and shows it to the user. The image is then muted according to the noise type selected by the user and the parameters set for the selected noise type, then displayed on the form. You can save an image, run an experiment (plot), define a shape, or noise the image again.

If you choose to save an image, the first step is to check whether the image can be saved, then the image is saved to a file with the specified name and extension.

If an experiment is selected, the number of tests, the type of noise, the noise parameters are determined, then the increment to the noise degree parameter is determined, and for each of the reference figures a series of experiments is carried out:

* The image is noisy from the minimum to the specified noise level
* After each noise is estimated KI and stored in an array of values KI.

After that, the values of KI are displayed on the chart, where each line corresponds to the KI values at different degrees of image noise.

If you select image definition, then for each reference figure is determined to the original relative to the reference, then select the minimum value of KI and remembered for which figure this value was the minimum. When this is done, the program will show a sample of the reference shape and display the shape name on the screen. You can also save the resulting image.

If you select the re-noise, the noise is carried out relative to the already noisy image, otherwise the noise is carried out for the original.

2 Recognition results

To compare the capabilities of the algorithm under study and the human visual system according to the classification of "blurred" images, figure 4 and 5 show images of simple geometric shapes (area S = 625 pixels) recognized by an automatic device implemented as a software tool. For the images in figure 4, the recognition threshold $W = W_{max}$, in figure 5, the images were distorted to their individual W_v thresholds. It is obvious that the images in figure 4 are shown to a lesser extent than in figure 5, which is a fee for excluding their incorrect recognition at $W = W_{max}$. In General, according to figure 4 and 5, it can be concluded that within the framework of this task, the efficiency of automatic recognition of blurred images is close to the efficiency of the human visual system

Thus, the above-proposed measured index of similarity between the image and the standard in form provides a sufficiently high efficiency of recognition of distorted images when passing through optical systems or media without taking into account a priori information about the degree of their "blur".

Fig.4. Images distorted to individual thresholds W_v:
1 - square; 2 - circle; 3 - diamond; 4 - trapezoid; 5 - right triangle.

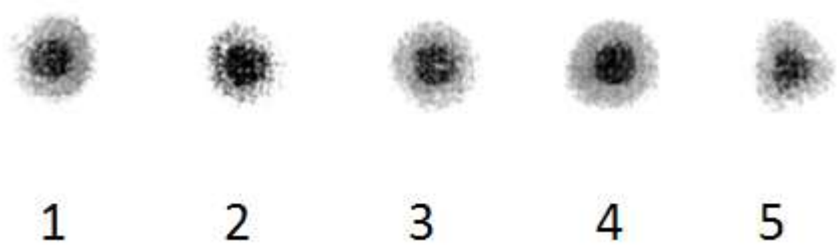


Fig.5. Images distorted to individual thresholds W_v:
1 - square; 2 - circle; 3 - diamond; 4 - trapezoid; 5 - right triangle.

For each type of noise, there is a certain value of the noise level at which the program stops correctly determining the reference images For noise type "Gaussian monochrome" the following threshold values were obtained:

Square-degree 4200; KI value-1,1300512728883
Round - the degree of 4130; a value of KI - 1,12543698834234
Rhombus - grade 4400; the value of KI - 1,12643149912134
A-line - degree 4350; a value of KI - 1,13357093373766
Right triangle - a 4100 degree; the value of KI - 1,126781459449

«Gaussian color»:

The square - degree of the 4400; the value of KI - 0,91648247891954
Round - the degree of 4350; a value of KI - 0,918156459591398
Rhombus-degree 4900; value KI-0.917142759509086
A-line - degree 4300; the value of KI - 0,915388786370116
Right triangle - degree of 4050; a value of KI - 0,915354674331766

«Gaussian blur»

Square-degree 19; KI value-0,394154110055535
Round - the degree of 21.5; a value of KI - 0,408772649106782
Rhombus-degree 22; value KI-0,372755526395548
A-line - degree 14; the value of KI - 0,361606294297676
Right triangle-degree 24; value KI-0,402003509124454

«Spray»

Square - grade 3; the value of KI - 0,601763233722686
Round - the degree 5; the value of KI - 0,668544297411066
Rhombus-degree of 8; value KI-0,646404502806758
A-line - degree 4; the value of KI - 0,669168646834291
Right triangle - the degree 6; the value of KI - 0,606404784725536

«Mosaic»

Square-degree 20; KI value-0,273543905599172
Round - 30 degree; the value of KI - 0,378621893443313
Rhombus - degree 40; the value of KI - 0,40252055209977
A-line - degree 30; the value of KI - 0,388925655293391
A right triangle is 35 degree; the value of KI - 0,317185860370666

3 Software implementation of the algorithm

When you start the application, at first you need to open the image (Fig. 6).

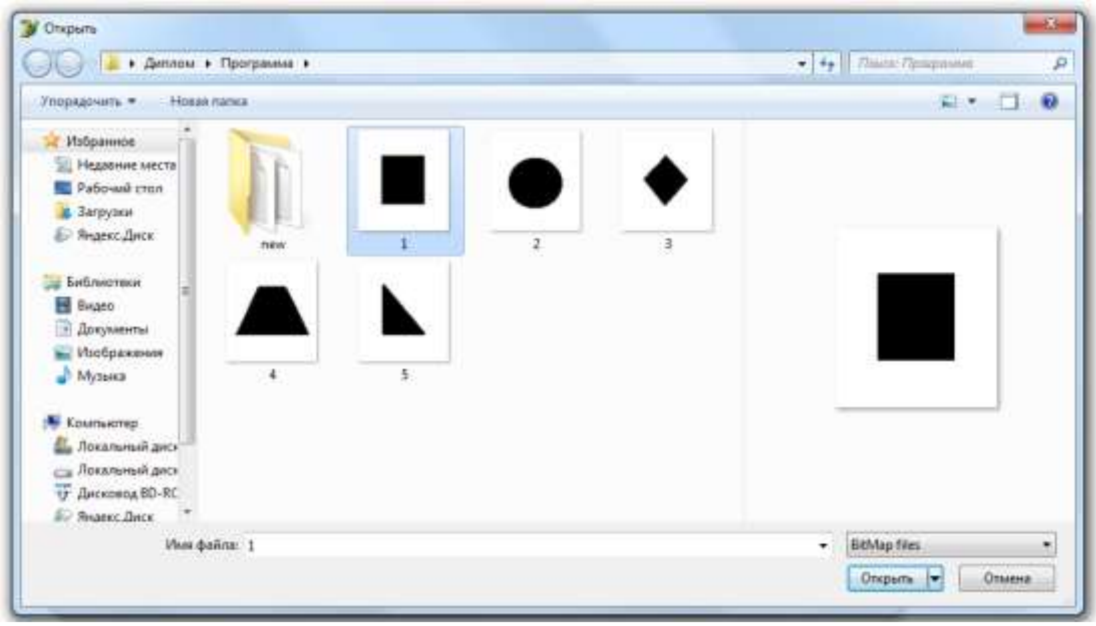


Fig.6. Opening the image

When you select an image, you can specify which images to open, bmp or jpeg. Thus, we exclude the possibility of opening files with the wrong format. After opening the image, the contents of the form will change as follows (Fig. 7).

The selected image will be displayed on the left side of the form, and information messages about what will be displayed on them will appear in the middle and right panels of images. After opening the image you need to make the original image distortion, for further definition of the image. To do this, it is proposed to choose the type of distortion that will be produced:

* Monochrome noise over Gauss
* Color noise by Gauss
* Spray
* To turn into a mosaic
* Blur

For the convenience of users, the primary parameters for all noise algorithms have already been made, but the user can change them at any time. Choosing the right panel the type of noise, at the top right of automatically changing the panel settings for the type of noise.

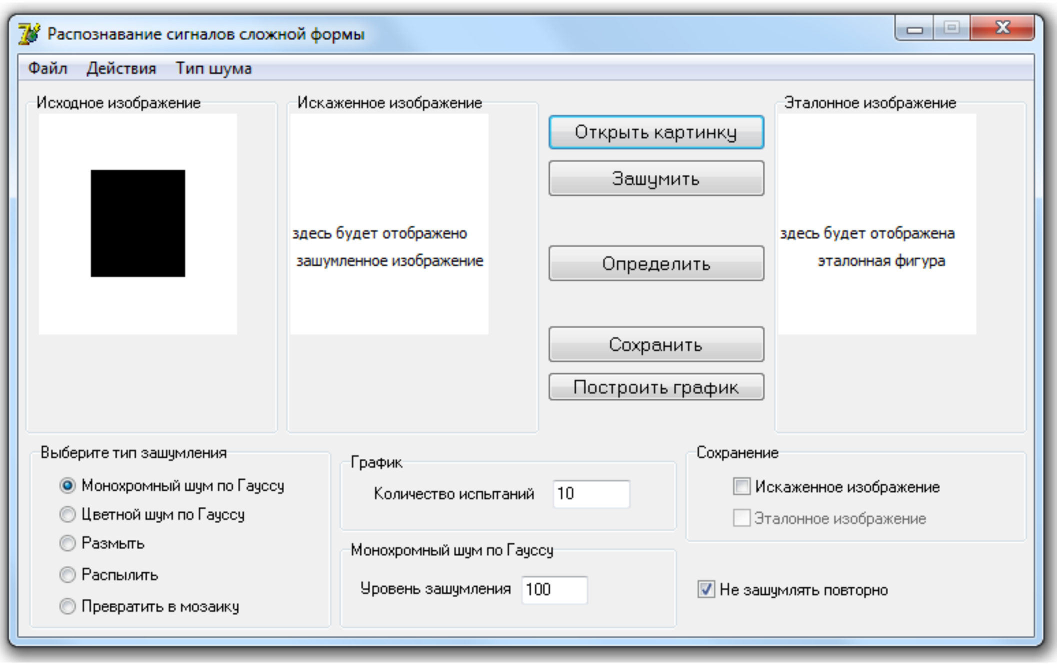


Fig.7. Adding a reference standard

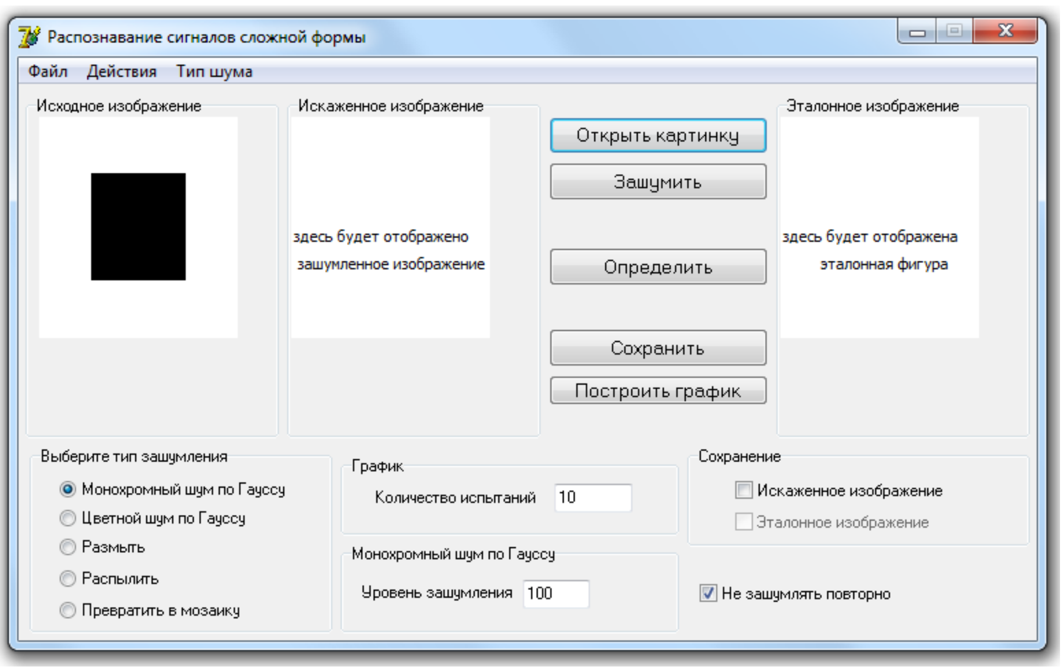


Fig.8. Variant for Gaussian monochrome noise.

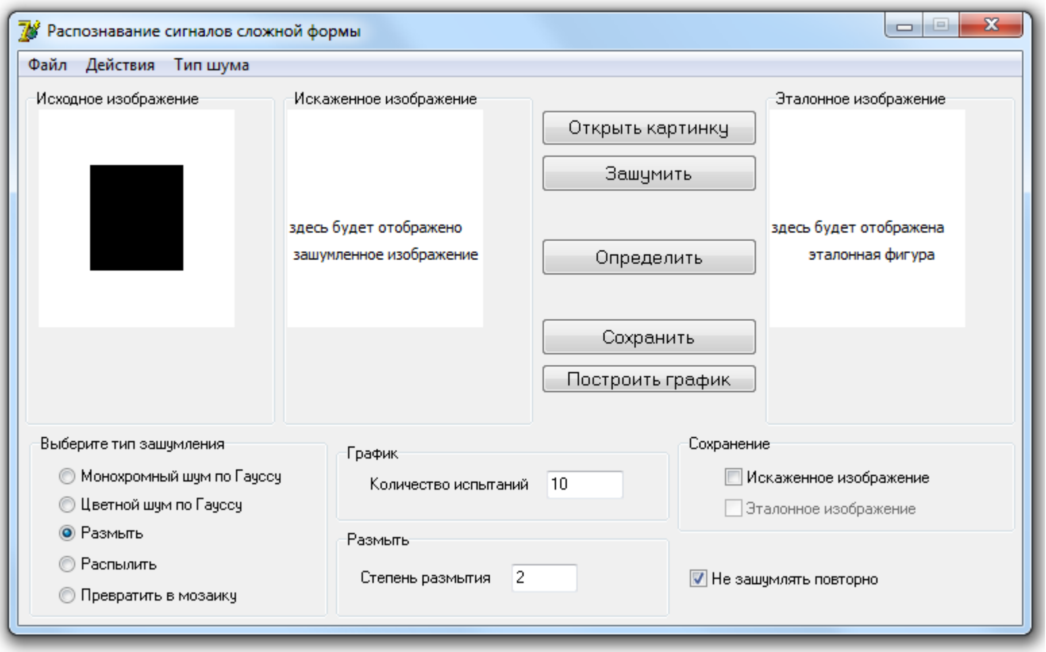
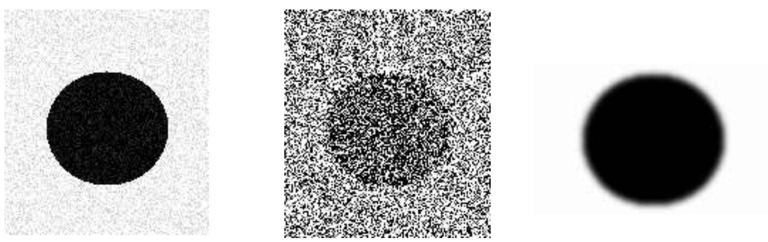


Fig.9. Changed the parameters panel for "Blur" noise.

Thus, we can adjust the noise level for each type of noise, for example (Fig. 8), (Fig. 9).

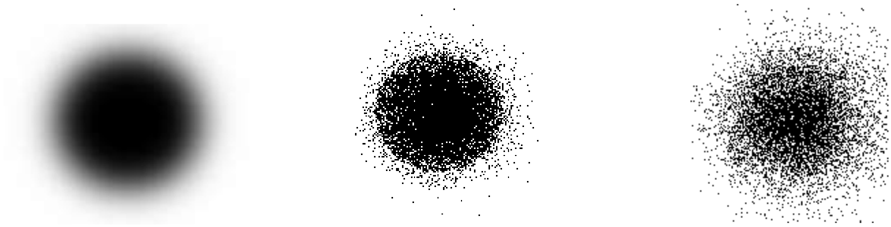
If the "Monochrome noise by Gauss" is considered, the points of white or black color are randomly applied to the image (Fig. 10 (a). By changing the noise level, we get a more or less noisy image (Fig. 10 (b). Image blur may be present (Fig. 10 (c).



a) b) c)

Fig.10.
a) Monochrome noise over Gauss.
b) Monochrome noise over Gauss, with stronger noise.
c) Gaussian blur.

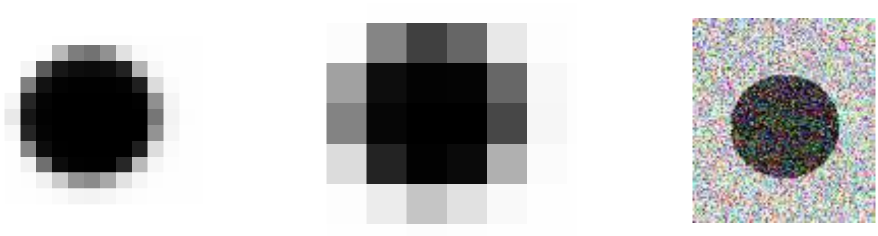
When increasing the degree of blur we get a more blurred image (Fig. 11 (a)). Analog of the "spray" effect in MS Paint (Fig. 11 (b)). Increase the depth of spraying (Fig. 11 (c)).



a) b) c)

Fig.11.
a) Gaussian blur, with a stronger degree of blur.
b) «Spray» Effect.
c) «Spray» effect, with increasing depth.

If you consider a "mosaic", the image is divided into rectangles of a given size and painted in medium color, using the arithmetic mean of the components. (Fig. 12).



a) b) c)

Fig.12.
a) Mosaic
b) Mosaic, when increasing the size of the rectangles
c) Gaussian noise with "color" noise

Thus, we see that by choosing the type of noise and adjusting the noise parameters, we can get different degrees of image distortion, which can continue to work.

It may be of interest to combine different types of noise, i.e. noise sequentially several types of noise.

To do this, you need to remove the check mark from the item "do not noise again".

4 Definition of a distorted image

Once all the necessary manipulations are carried out, you can proceed directly to the definition of the image. (fig.13).

The principle of estimation of the total standard deviation from the reference figure is used for determination.

The program compares the distorted image to each of the available benchmark figures, estimates of the total standard deviation, and draws a conclusion about what the image depicts, on the basis of the minimum value of standart deviation. The reference figure, when compared with which this minimum standart deviation was obtained, is recognized as the image on the distorted image.

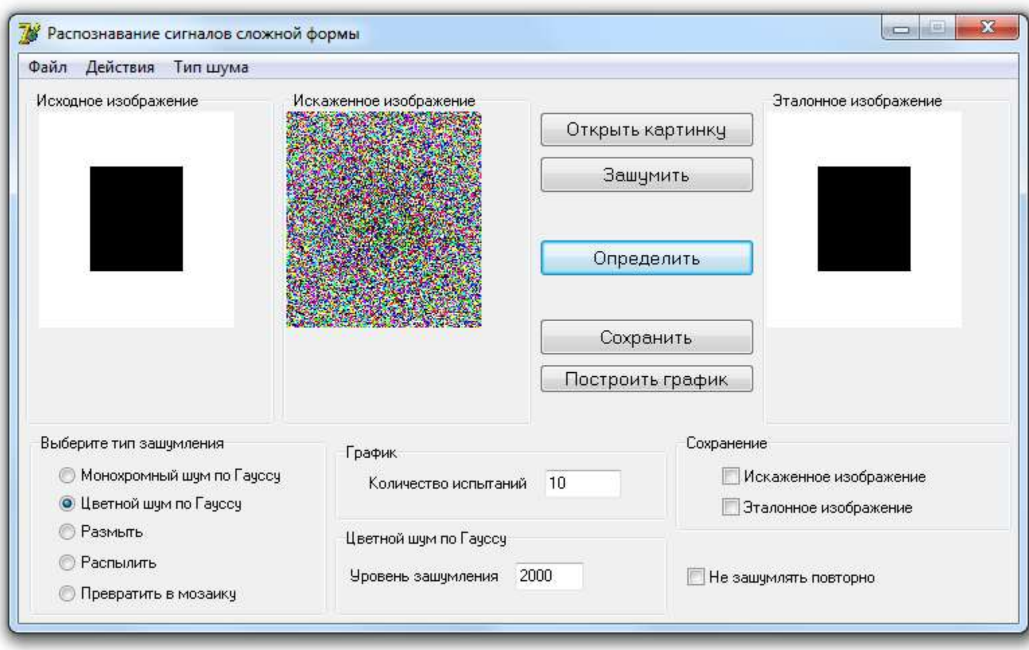


Fig.13.-Image Recognition

The figure that was recognized as the reference for the current distorted image is recognized as the reference for the current image, is displayed in the "Reference image" panel and its name is displayed in the lower part of the main window.

The program provides for the possibility of studying the dependence of the values of standart deviation in relation to different reference figures, depending on the type of noise and noise parameters.

To conduct tests and plotting, you must select the type of noise for which the dependence will be studied, enter noise parameters, and the number of tests.

Tests are conducted in the intervals of noise parameters from the minimum to the specified.

Each line on the graph corresponds to the standart deviation of the distorted image from the reference. (figure 14).

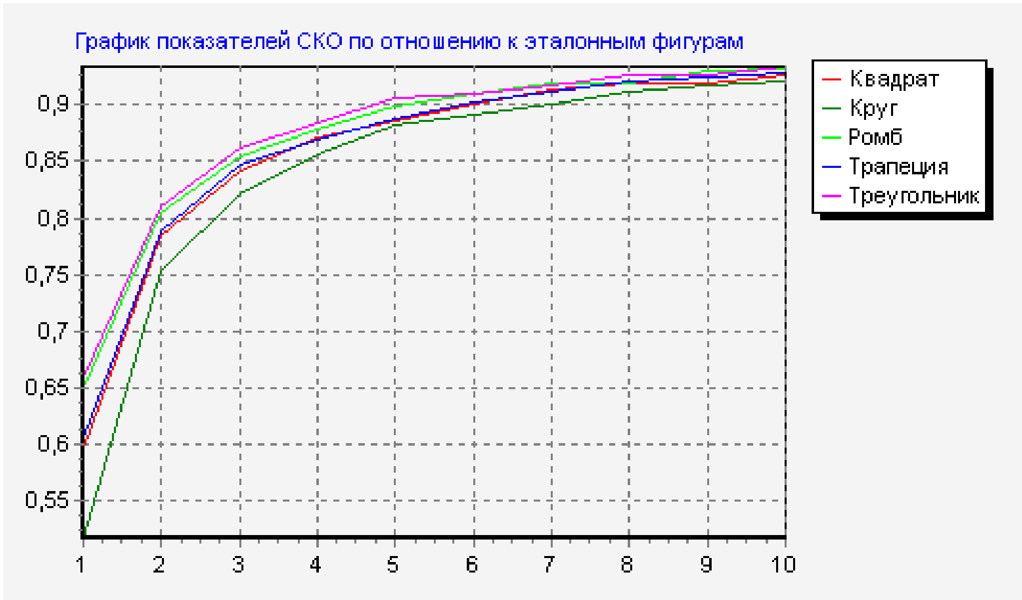


Fig.14. Graph of standart deviation

The graph shows that the more noise occurs, the closer the values of standart deviation for different reference figures. Another example (distortion circle, the noise is "mosaic", when values of the 50x50) (Fig. 15). Each image can be saved with the name selected manually or with the program.

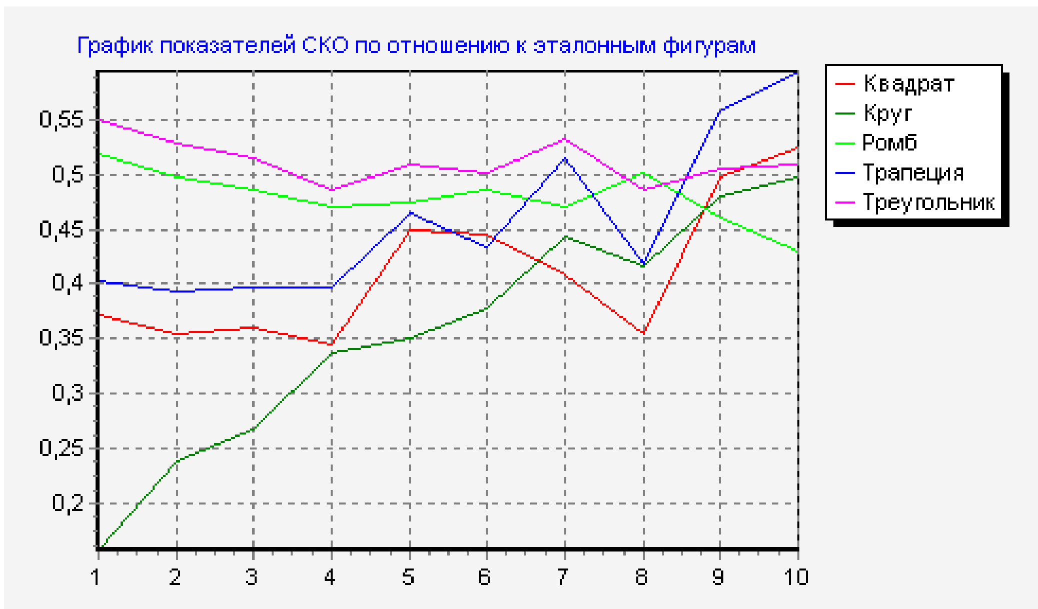


Fig.15. Graph of standart deviation the distortion of the circle.

Conclusion

The model and the algorithm of image recognition based on the correlation approach are constructed. The results of recognition for different types of images and noise are obtained.

On the basis of the developed recognition algorithm, a software product is created in the programming environment. This product allows you to analyze the possibility of recognition for different types of noise and has a fairly simple and intuitive interface.

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Prof. Oleg Choporov
Doctor of Sciences (Engineering), professor,
Voronezh Institute of High Technologies, Russia
choporov_oleg@mail.ru

Prof. Andrey Preobrazhenskiy
Doctor of Sciences (Engineering), associate professor,
Voronezh Institute of High Technologies, Russia
app@vivtl.ru

Assoc. Prof. Eugen Ružický, PhD.
Faculty of Informatics, Pan-European University, Bratislava, Slovakia
eugen.ruzicky@paneurouni.com