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USING SIGNATURE ANALYSIS IN GRAPHIC PATTERN RECOGNITION

Abstract: On the basis of the signature analysis it is entered various concepts: the sample containing information and procedural parts and contour function. The identification methodology graphic objects invariant to affine transformations on the basis of concept of contour function is stated.

1. Introduction

Lately there was a set of new methods of processing of images. It has a talk one side with occurrence of new directions of their application, and on the other hand constant increase of power of computer facilities. However work in well-known directions of researches too can yield good results. The signature analysis concerns one of such well studied areas also.

For understanding of an essence of this direction it is necessary to state two theses which lie in its basis. First, it is necessary to remind that any image of object is some two-dimensional function. And to identify such function difficult enough. Therefore one of overall objectives of the signature analysis is transformation of two-dimensional function of object on the image to one-dimensional function. In the second the main moment of the signature analysis is use of the centre of gravity of identified object. Concerning this centre of gravity identified function also is under construction. It is a lot of methods of construction of such function. They concern:

- *Function of border points* with a sample equable step $\Delta t = const$.
- *Function of angular turn* at equal distance between points.
- Replacement of border with n-range with equal sides and after that *function evaluation of the relation of a corner between the side and a radius-vector* to this side (a variant distance function between the centre of gravity and tops of range or the centers of each side of this range is).
- *Function of distance from the centre to points with high curvature* (with direct calculation of curvature or with reception of polygonal approximation of the form and use of points of interface as central with high curvature). Full enough review of signature methods is brought in the book [1] and articles [2,3].

In the present work will methods of identification of contours of graphic objects which have been received on the basis of function of points of border with a sample even stride are in detail considered.

2. Concept of contour function

Let's enter some abstract description of some graphic object. It is obvious that such description should consist of two components. First, it is a informative component on which basis it is possible to lead object identification. In the second it is a procedural part, that is that sequence of methods and operations by means of which the first part has been received.

Thus it is possible to present the description of some object as a vector of properties of the sample and to write it in the form of some pair consisting of information and procedural parts $\vec{x}_s = \{I_s, \vec{\theta}_\lambda\}$, where I_s - an information part of a vector of the sample, and $\vec{\theta}_\lambda = \left\{\vec{\theta}_{\lambda_1}, \vec{\theta}_{\lambda_2}, ..., \vec{\theta}_{\lambda_Q}, \vec{\varepsilon}_\Sigma\right\}$ - the expanded vector of parameters of functions of processing of images λ_q.

Let's consider concept of an information component - I_s for some vector of the properties, attributed to some object [4]. We will define it as the set of properties I consisting of subsets $I^{(i)} \subset I,\ i = \overline{0,n}$. The index i means subset level. So, for example, $I^{(0)}$ will be a subset of primary properties, $I^{(1)}$ - the secondary properties received by performance of some functions over primary, etc. Thus, all information part of a vector of properties can be described as: $I = \bigcup_{i=0}^{n} I^{(i)};\quad I^{(i)} \bigcap I^{(j)} = \varnothing;\quad i \neq j$.

Besides, the situation, when is possible $I^{(i)} = F(I^{(i-1)}, I^{(i-2)}...)$. And in real cases some subsets $I^{(i)}$ can be empty or not be used, and recognition process can be constructed with use as properties of separate levels, and their combinations.

Let's bring examples of the description of subsets $I^{(i)}$ [5]. Let set of coordinates $(x_i, y_i),\ i = \overline{1,k}$ form a contour of some graphic object (fig. 1). Set $I^{(0)}$ of primary vectors of properties we will define as set of points on a plane: $I^{(0)} = \{i_l^{(0)} = (x_l, y_l),\ l = \overline{1,k}\}$,
forming a contour of graphic object, and where k there is a quantity of points of perimeter of this object.

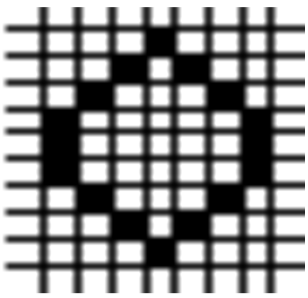

Fig. 1. Example of object consist from 16 points

Let the set $I^{(0)}$ of some object is defined. We name an element of set of secondary properties $\xi_0^{(1)} = \nu_0(I^{(0)}) \in I^{(1)}$ “the object centre of gravity” if:

$$\xi_0^{(1)} = (x_c = \frac{1}{k}\sum_{l=1}^{k} x_l,\ y_c = \frac{1}{k}\sum_{l=1}^{k} y_l) .$$

Definition 1. Let's enter the formal description of signature function as follows. Let elements of sets $I^{(0)}$ and $I^{(1)}$ for some object are defined. We name functional of transformations of the signature of a contour $r = \nu_3(\nu_2(\nu_1(I^{(0)}, I^{(1)})))$ the following sequence of the functions ν applied to set $I^{(0)}$ and $I^{(1)}$:

1. $I^{(0')} = \nu_1(I^{(0)}, I^{(1)})$, where ν_1 - function of transformation from the Cartesian co-ordinates to polar in a kind $(R,\varphi) = \{((x - x_c)^2 + (y - y_c)^2)^{1/2}, arctg\frac{x}{y}\}$, that is set receptions $I^{(0)}$ in polar coordinates - $I^{(0')} = (R_l, \varphi_l)$, $l = \overline{1,k}$.
2. $I^{(0'')} = \nu_2(I^{(0')})$, where ν_2 - function of sorting of set $I^{(0)}$ on a corner φ as its increase. Further it is supposed that if there are two and more points an identical corner the point with the maximum value of a vector gets out R.
3. $r = \nu_3(I^{(0'')})$, where ν_3 - function of interpolation of points of object on all circle with the set fixed step defined as $\Delta\varphi = 0.5, 1, 2...$ angular degree that gives 720, 360 and 180 … points of development of an investigated contour, depending on demanded accuracy of representation of object.

<u>The remark.</u> *It is obvious that transformations ν_1 and ν_2 will be unequivocal only for convex contours of graphic objects. However it is necessary to notice that these transformations are carried out concerning the object centre of gravity. That is the concept of camber here is defined through number of lines of a contour of object which will be crossed by a beam going from its centre of gravity. For convex object this number should be always equal 1 in this sense. Otherwise there are ambiguity in performance of transformations ν_1 and ν_2, definitions resolved on 3 point.*

Examples of development of contour functions are brought on fig. 2.

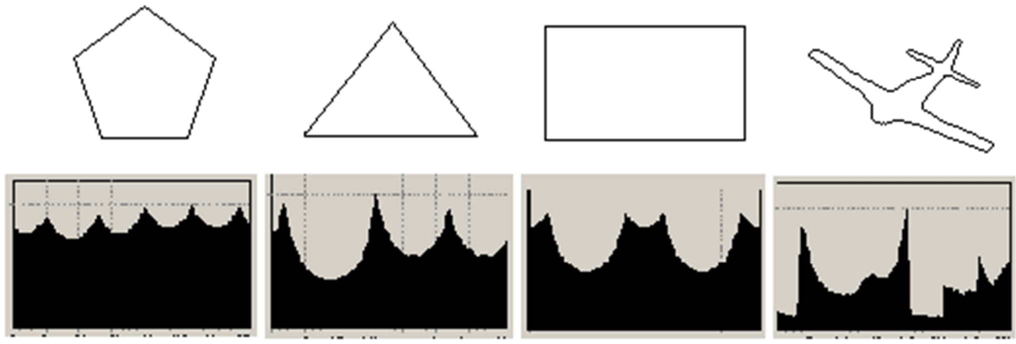

Fig.2. Example of contour functions.

Definition 2. Let on [0,360 °] function r is defined. Normalize function r_N we will name r -function, rationing concerning a maximum accepted by it on an interval [0,360 °]. Rationing factor we name number $\eta = 1/r_{\max}$. Where $r_{\max}$ - the maximum value accepted by function r on an interval [0,360 °]. Further with a view of record simplification we will lower an index N, meaning that function r always normalizes.

Let's define process of reception of vectors of properties of the graphic objects located on the image Im, as some sequence of operators:

$$\mathrm{Im}_i = f_i(\mathrm{Im}_{i-1}, \theta_{f_i}, \tau_{f_i}), i = \overline{0,k}; \quad (1)$$

Where $\forall f_i(\theta) \in F = \{f_1, f_2, ... f_m\}$ - there are functions of transformation of the images, forming set F; $\forall \theta_f \in \Theta = \{\theta_1, \theta_2, ... \theta_m\}$ - there are parameters of functions f_i forming set Θ; and $T = \{\tau_{f1,} \tau_{f2,} ... \tau_{fl,}\}$ there is a set of parameters which defines quantity of functions f_i and sequence of their application.

The remark. Functions f_i, its description, domain of definitions and area of values should be considered separately in real application for real object.

The ultimate goal of processing of any image Im puts a problem of reception of the formal description (in some kind) the graphic objects located on the image. That is the end result (1) will be some uniform description of set of objects ω_{Im} which contains as the objects belonging to a required class, and objects of other classes (including noise objects).

It is obvious that values of properties of any graphic object, presented in the form of a vector of properties x_i, depend not only on image parameters Im (brightness, contrast, spectral density, level of noise and distortions), but also from methods f_i, values of parameters of these methods θ_{f_i} and sequence of their application τ_{f_i}.

3. **Building of recognition function**

Let's write down now *the function of recognition* λ based on calculation of some metrics in space of properties, such that

$$\lambda = \begin{cases} 1, & \rho(\vec{x}_{\mathrm{Im}}, \vec{x}_s) < \varepsilon, \\ 0, & \rho(\vec{x}_{\mathrm{Im}}, \vec{x}_s) \geq \varepsilon. \end{cases} \quad (2)$$

here $\vec{x}_{\mathrm{Im}}$ and $\vec{x}_s$ - a vectors of properties of current and sample objects; ρ - some metrics, and ε - the classification tolerance of recognition. If $\rho < \varepsilon$ that we consider that the vector $\vec{x}_{\mathrm{Im}}$ belongs to a class ω_s if $\rho \geq \varepsilon$ that does not belong. Also, we will believe that the procedural part of a vector of properties of object $\vec{x}_{\mathrm{Im}}$ in this function is not used.

Let the set ω_{Im} is formed by vectors of properties of all graphic objects allocated from the image Im. We will present process of their identification in the form of sequence of application of various functions of recognition λ to set elements ω_{Im}:

$$\omega_{\mathrm{Im}}^{q} = \lambda_q(\omega_{\mathrm{Im}}^{q-1}, \overline{x}_s, \overline{\theta}_{\lambda_q}, \varepsilon_{\lambda_q}), \; q = \overline{1,Q};, \quad (3)$$

$$\omega_{\mathrm{Im}}^{q} \subset \omega_{\mathrm{Im}}^{q-1} \subset \ldots \subset \omega_{\mathrm{Im}}^{0}, \quad (4)$$

where $\omega_{\mathrm{Im}}^{q-1}$ and ω_{Im}^{q} - subsets from ω_{Im} on $q-1$ and q-th stages of recognition; λ_q - the functions forming set of methods of recognition Λ; $\vec{\theta}_{\lambda_q} = (\gamma_1, \gamma_2, \ldots, \gamma_m)$ - a vector of parameters of function λ_q; ε_{λ_q} - the classification admission for λ_q; Q - number of used methods of recognition. Expression (4) means that the objects not recognized on a q-step, are rejected from the further consideration.

Definition 3. Order of application of functions λ_q in (3) we will name *a method of consecutive weighing* (MCW) [2] and to represent as:

$$\lambda_{\Sigma} = \{\lambda_1, \lambda_2, ..., \lambda_Q\}. \quad (5)$$

In (3-5) initial set of vectors of properties ω_{Im} is accepted for ω_{Im}^{0}, and result of performance (3) will be required set of the distinguished objects ω_{Im}^{R}.

4. Method of identification on based of signature analysis

Let's consider some methods of identification of the objects, based on the signature analysis and used in a method of consecutive weighing.

4.1. Classification by a contour is the simplest method based on comparison of quantity of points in object.

Definition 4. We name $\lambda_R = \begin{cases} 1, |n_Э - n_O| < \varepsilon_N \\ 0, |n_Э - n_O| \geq \varepsilon_N \end{cases}$; *recognition function by quantity of points*.

Here $n_Э$ and n_O are quantity of points of a contour of the sample and tested object accordingly, and ε_N - the classification tolerance which defines accuracy of comparison of objects.

Despite simplicity, this method is of great importance in MCW as he allows to "eliminating" set of the objects having "the noise" nature at the first stage of process of recognition. On fig. 3 the whirlwind in atmosphere of Jupiter is represented. Its contour contains from approximately 500 points while other objects it is much less - 100-200. Thus, defining an admission interval for this purpose object equal $400 \le \varepsilon_N \le 600$ it is possible to eliminate all unnecessary objects and to watch development of this whirlwind.

Fig. 3. At the left the fragment of a photo of Jupiter with an atmospheric whirlwind is represented. In the middle the same fragment on one of stages of processing of the image is represented. On the right results after reception of contours, before the beginning of process of recognition are represented. It is easy to notice that using of difficult methods of recognition here is not required and enough to use identification by quantity of points for defect definition.

The remark. *This method of recognition does not use the information about the form of object and, hence, it can be applied for recognition of objects, the verbal description of the form which it is not necessary or is not obviously possible for receiving.*

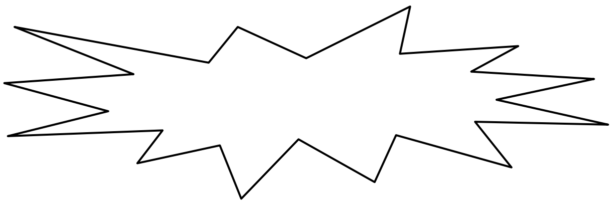

Fig. 4. How may describe dimensions this object?

4.2. Classification by shape dimensions. We name this method "recognition on dimensions" or LH - a method. Before to define this method it is useful to ask some questions. And what mean shape dimensions for the object represented in fig. 4. How to measure these dimensions? And if it is necessary to recognize the objects turned on some corner, concerning the sample?

Definition 5. Let r_N it is defined on an interval [0,360 °] with step 1° then we name shape dimensions of graphic object the following three of parameters $\{i_1, i_2, i_3\} \in I^{(3)}$ such that:

$$i_1 = l_1 + l_2,\ l_1 = \max(r_N(\tau)),\ \tau \in [0, 360^\circ],\ l_2 = r_N(\tau_{\max} + 180^\circ); \qquad (6a)$$

$$i_2 = h_1 + h_2,\ h_1 = r_N(\tau_{\max} + 90^\circ),\ h_2 = r_N(\tau_{\max} + 270^\circ); \qquad (6b)$$

$i_3 = \tau_{\max}$, than $r_N(\tau_{\max}) = l_1$. (6c)

Let's define *recognition function on dimensions* λ_{LH} in a kind:

$$\lambda_{LH} = \begin{cases} 1, ((|\frac{i_1^S - i_1^O}{i_1^S}| < \varepsilon_l) \bigcap (|\frac{i_2^S - i_2^O}{i_2^S}| < \varepsilon_h) \bigcap (|\frac{i_3^S - i_3^O}{i_3^S}| < \varepsilon_\varphi)) \\ 0, \quad \text{otherwise.} \end{cases}$$

Here ε_l , ε_h и ε_φ - the classification tolerance defining accuracy of recognition on length, on height and an object's angle of rotation.

It is possible to expand such treatment of concept of dimensions by introduction of additional parameters i_j, such that $i_j = h_{j_1} + h_{j_2}$, $h_{j_1} = r_N(\tau_{\max} + \varphi_j)$, $h_{j_2} = r_N(\tau_{\max} + \varphi_j + 180^\circ)$, $j = 3,4...$,

where i_j will play a role of "additional" dimensions. Such parameters can rise in certain cases quality of recognition (to increase probability of correct recognition and to reduce probability of the admission of objects of recognition). At aspiration of quantity of parameters i_j to quantity of readout of function r_N actually we come to the method of *geometrical correlation* stated more low.

4.3 Classification by the area. Concept consideration to "the figure area" leads to necessity of calculation of double integral of a kind (0-th moment of inertia of object) $A = \int\int \mathrm{Im}(x, y)dxdy$.

Using concept of contour function it is possible to enter concept of the surrogate area of object in the form of the area lying under contour of object and calculated as the sums of the areas of the triangles having the basis on perimeter, and the sides - radiuses-vectors concerning the centre of gravity. On fig. 5 fragment of such area is painted over by grey color.

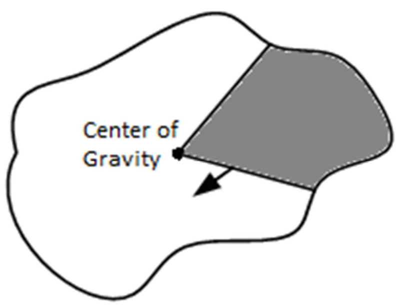

Fig. 5. Calculation area of object from contour function conception.

4.5. Geometrical correlation #1-2. For an explanation of concept of geometrical correlation we will enter any auxiliary functions.

Definition 6. Let is a set of points in polar to system of coordinates $g_i \in G^{(0)} = [0, 360°]$, so $g_i \le g_{i+1}$, $i = \overline{0, M}$, where $M = 360 \cdot k$, $k = 1/3, 1/2, 1, 2, ...$, and $\Delta g = g_{i+1} - g_i = const$. Let functions $x(\varphi)$ and $y(\varphi)$ are defined and continuous on $G^{(0)}$. We will write $\eta_{xy}(\varphi, \tau)$ as *function of a difference* of values x and y in discrete points of an interval $G^{(0)}$:

$$\eta_{xy}(\varphi, \tau) = x(\varphi) - y(\varphi - \tau) \quad \varphi, \tau \in G^{(0)}. \tag{7}$$

Let's define *function of a deviation* $\delta_{xy}(\tau)$ for x and y in discrete points on $G^{(0)}$ as:

$$\delta_{xy}(\tau) = \frac{1}{360} \sum_{\varphi=1}^{360} \left| \eta_{xy}(\varphi, \tau) \right|, \text{ where } \varphi, \tau \in G^{(0)}. \tag{8}$$

Deviation function $\delta_{xy}(\tau)$ expresses an average deviation of function x from function y on the interval $[0, 360°]$, at shift of function y concerning function x on some corner τ.

Definition 6. Let x - contour function of the sample, and y - some object. For the metrics $\rho_{G1} = \min_{\tau} \delta_{x,y}(\tau)$ we will define *recognition function on the basis of geometrical correlation #1* (GC1) as:

$$\lambda_{G1} = \begin{cases} 1, \rho_{G1} < \varepsilon_{G1} \\ 0, \rho_{G1} \ge \varepsilon_{G1} \end{cases};, \tag{9}$$

Where ε_{G1} there is a classification tolerance of recognition on GC1.

Now if $\lambda_{G1} = 1$, number of the classified object in the list of analyzed objects, its coordinates and some value of a corner τ corresponding to a minimum δ are results of recognition. The corner τ defines an object angle of rotation in relation to the sample.

Function ρ_{G1} considers all deviations of the form for recognized object, concerning the sample. Accuracy of recognition of this method that above, than large quantity of points M is used at calculation ρ_{G1} in functions x and y.

It is necessary to notice that computing complexity of metrics GC1 does not depend on complexity of the form of object. It increases with growth of number of points of set G, as well as accuracy of identification.

Definition 8. Let the function $\sigma_{xy}(\varphi, \tau)$ calculated as *an function average deviation* between functions $\eta_{xy}(\varphi, \tau)$ (7) and $\delta_{xy}(\tau)$ (8) on $G^{(0)}$ looks like:

$$\sigma_{xy}(\tau) = \frac{1}{360} \sum_{\varphi=1}^{360} | \delta_{xy}(\tau) - \eta_{xy}(\varphi, \tau) |, \tag{10}$$

where $\varphi,\tau\in G^{(0)}$, then for the metric $\rho_{G2}=\min_{\tau}\sigma_{x,y}(\tau)$ we will write *recognition function on the basis of geometrical correlation #2* (GC2) as:

$$\lambda_{G2}=\begin{cases}1,\ \rho_{G2}<\varepsilon_{G2}\\ 0,\ \rho_{G2}\ge\varepsilon_{G2}.\end{cases};, \qquad (11)$$

Where ε_{G2} there is a classification tolerance of recognition on GC2.

Now if $\lambda_{G2}=1$, number of the classified object in the list of analyzed objects, its co-ordinates and some value of a corner τ corresponding to a minimum σ is result of recognition. Value τ will define an angle of rotation of the recognized object in relation to the standard.

As example of the recognition of the form complex object on base of the method to GC#1 fragment of the scene of the Balice Airport (Krakow, Poland) expressed on fig. 6. The recognized planes noted arrow.

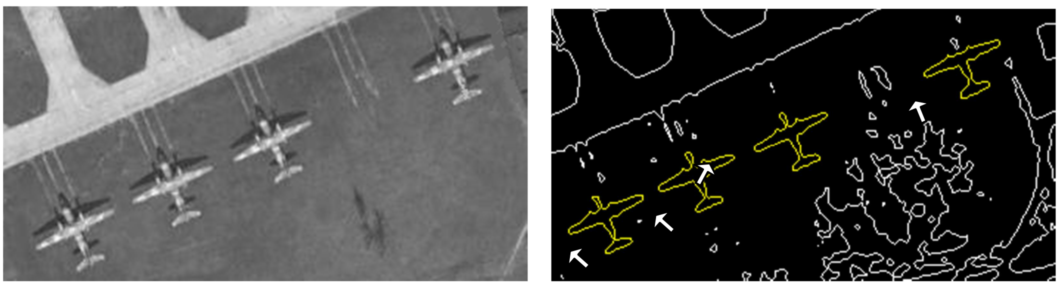

Fig. 6 At the left to show fragment of Balice Airport, Krakow, Poland. From write – this image after processing. The recognized planes noted white arrow.

5. The sophisticated methods of identification on the based of the signature analysis

We will consider one of the most comprehensive methods of identification of graphic objects on the basis of contour functions. As in a real case the contour seldom remains not deformed on all its length, accuracy of identification by methods of geometrical correlation GC1 and GC2 decrease with increase in quantity of fragments of the deformed contour. However accuracy of the methods is so great that supposes use only several fragments of a contour. Use of the demands of signature analysis, that these pieces have been located opposite each other. Thus we will construct *system of opposite intervals* in a following kind.

Definition 9. We will name *set of opposite intervals* G_p - set of such fragments of a contour of equal width (in angular degrees or contour points) that:

1. $g_l^p=\left[\tau',\tau''\right],\ \tau'\le\tau'',\quad \tau',\tau''\in\left[0,360^\circ\right]\ g_l^p\bigcap g_m^p=\varnothing,\ l\neq m$ (12)

2. The width and an arrangement $g_l^p\ g_{l+1}^p$ is rather defined as

$$\tau'_{l+1} = \tau'_l + 360° / L,\ L \geq 2,\ 0 \leq |\tau'' - \tau'| \leq 360^{\circ}/L,\ |\tau''_l - \tau'_l| = |\tau''_m - \tau'_m|\ \forall l, m = \overline{1, L} \quad (13)$$

3. Initial position g_l^p is fixed and set by displacement ψ

$$\tau'_1 = \psi;\ \psi \in [0, 360° / L]. \quad (14)$$

Here L - number of opposite intervals on $\left[0, 360^{\circ}\right]$ and the argument τ always submits to a rule $\tau + 360° = \tau$. The examples of opposite intervals located on a circle, are shown on fig. 7.

Fig. 7. Examples of opposite intervals for l = 2, 3, 4, 5, 6.

As the arrangement of distortions on a real contour a priori on is defined, in the course of identification we will change initial position of these opposite intervals.

***Definition 10*.** Let $G^{(0)}$ is a set of points on $\left[0, 360^{\circ}\right]$ in polar system of coordinates. We will enter transformation function υ, such that $\upsilon : G^{(0)} \to G'_p$, or taking into account its parameters we will write down:

$$G'_p = \upsilon(L, G_p, \psi), \quad (15)$$

where L - the number of segments g_c^p with a width $\tau'' - \tau'$, and ψ - is displacement angle of set G_p from some initial position.

The number of points $G^{(0)}$ and, hence G'_p, characterizing accuracy of identification is calculation under the formula $N_G = 360k/l$ where indexes k, l can accept values 1, 2, 3...

Function use υ shows that the location of set of the resisting intervals G_p, defined in (12) - (14), has dependence on displacement angle ψ. At $\psi = 0$ set G'_p it is completely compatible with G_p, and then, in the course of identification, its position will be displaced on some corner $\Delta\psi$ on all range of definition range ψ from (14).

Definition 11. Let in functions $\eta'_{xy}(\varphi, \tau)$, $\delta'_{xy}(\tau)$ and $\sigma'_{xy}(\tau)$ from (7), (8) and (9) the variation of a corner $\psi = \overline{0, 360^{\circ}/L}$ for area G'_p is entered, then their record taking into account dependence on argument ψ looks like is:

$$\eta'''_{xy}(\varphi,\tau,\psi) = x(\varphi-\psi) - y(\varphi-\tau)\,, \tag{16}$$

$$\delta'''_{xy}(\tau,\psi) = \frac{1}{N}\sum_{\varphi\in G'_p}\left|\eta'''_{xy}(\varphi,\tau,\psi)\right|, \tag{17}$$

$$\sigma'''_{xy}(\tau,\psi) = \frac{1}{N}\sum_{\varphi\in G'_p}\left|\delta'''_{xy}(\tau,\psi) - \eta'''_{xy}(\varphi,\tau,\psi)\right|, \tag{18}$$

where $\varphi\in G'_p$, $\tau\in\left[0,360^\circ\right]$, $\psi\in\left[0,360^\circ/L\right]$, $\upsilon(\psi)=\psi+t$, and $t=const$ there is a size of a step of shift of set G'_p. The second argument in function x from (16) shows that initial position G'_p in contour function of the sample depends on a corner ψ.

It is necessary to notice once again that the result of process of identification will be defined by position of the set G'_p set by a corner ψ in (15), which allows to rotate opposite intervals (sample) along a contour, for definition of such position in which parts of perimeter are not damaged, and to use these fragments for recognition. Thus, the corner ψ is used as optimization parameter in following definitions.

Definition 12. For the metrics of type $\rho_{a1} = \min\limits_{\psi}\left(\min\limits_{\tau}\delta'''_{xy}(\tau,\psi)\right)$ calculated on function $\delta'''_{xy}(\tau,\psi)$ (17), on set G'_p we will write *function of identification with an automatic choice of an arrangement of parts of a contour on opposite intervals* # 1 (A1) as:

$$\lambda_{a1} = \begin{cases} 1, & (\rho_{a1} < \varepsilon_{a1}) \\ 0, & (\rho_{a1} \ge \varepsilon_{a1}) \end{cases}; \tag{19}$$

Where ε_{a1} there is classification tolerance АВЧК1,

Definition 13. For the metrics of type $\rho_{a2} = \min\limits_{\psi}\left(\min\limits_{\tau}\sigma'''_{xy}(\tau,\psi)\right)$ calculated on function $\sigma'''_{xy}(\tau,\psi)$ (18) on set G'_p, we will write *function of identification with an automatic choice of an arrangement of parts of a contour on opposite intervals* #2 (A2) as:

$$\lambda_{a2} = \begin{cases} 1, & (\rho_{a2} < \varepsilon_{a2}) \\ 0, & (\rho_{a2} \ge \varepsilon_{a2}) \end{cases}; \tag{20}$$

Where ε_{a2} there is classification tolerance АВЧК2.

In formulas of metrics (19) and (20) it is necessary to examine at minimum functions from two variables. At practical realization of these formulas, the minimum at first is searched on τ, then set shift G'_p on some discrete a corner $\Delta\psi$ (used in function x in (16)) is made. This operation of search of a minimum on τ is consistently carried out for all definition range ψ.

The resulting value compared to the classification tolerance, gets out of a minimum of minima $\delta'''_{xy}(\tau,\psi)$ or $\sigma'''_{xy}(\tau,\psi)$ on τ, received at passage on all points ψ from $\left[0,360^\circ/L\right]$ with step t.

6. **Conclusion**

The considered methods of identification of objects on the basis of geometrical correlation give the chance to recognize the form of objects with high accuracy to invariant to 2d - affine transformations and mirror reflection in real time. Sensitivity of methods is very high and increases with increase of cardinality of a set G. Use of these methods allows not only to identify the form with in a priory given accuracy, but also to recognize separate fragments of contours on the objects having the similar form.

The examined methods have both positive and negative sides. It shows that at any direction of recognition of graphic objects, methods have area of its applicability. Research of the approach on the basis of the signature analysis shows, that its permit solves tasks in broad range of problems in a science and the technician.

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