Research of Recognition of the Imposed Flat Objects on Dimensionless Marks of their Contours

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Abstract: *The purpose of work is the pilot study of recognition of the imposed flat objects on the basis of dimensionless marks of their contours and definition of a possibility of use this method in technical sight system.*

Keywords**:** image; recognition; details; imposed objects; dimensionless marks.

1. INTRODUCTION

Operation of sorting details when developing algorithms of processing their images in technical sight systems (TSS) can be formulated as a problem of image recognition perceived by a video camera of system. For this purpose the received images are exposed to processing and the analysis [1].

Details on the conveyor can settle down isn't ordered in the separate and imposed look [2,3]. The problem of recognition of the flat details which are separately lying on a tape is almost solved [1,4] while the question of identification of the imposed flat objects requires the solution.

Results of pilot studies of algorithm of recognition the imposed flat objects on dimensionless marks of contours of their bitmaps are given in this article. Ways of extraction basic and formations of dimensionless marks of flat objects on their contours are given in [5-8]. Distinctive feature of the applied dimensionless marks, that they are invariant to turn, transfer and change of scale of objects in sight of TSS.

2. DESCRIPTION OF RECOGNITION ALGORITHM

During pilot studies casual emergence of the imposed objects in technical sight system was imitated. For each class of imposing of the generated and real images of flat objects considered test presentational selection on 2000 images of each class of the imposed images is formed.

Examples of separate test (STFO) and real (SRFO) of flat objects are given in Fig. 1 and 2.

From 10 STFO or SRFO it is possible to create 100 options (types, classes) of their imposing at each other, considering cases when: the object P from below, and object of T from above and vice versa, or object is imposed on itself. For experiments 55 options of imposing formed when object P from below have been used, and the object of T from above and each object is imposed on itself.

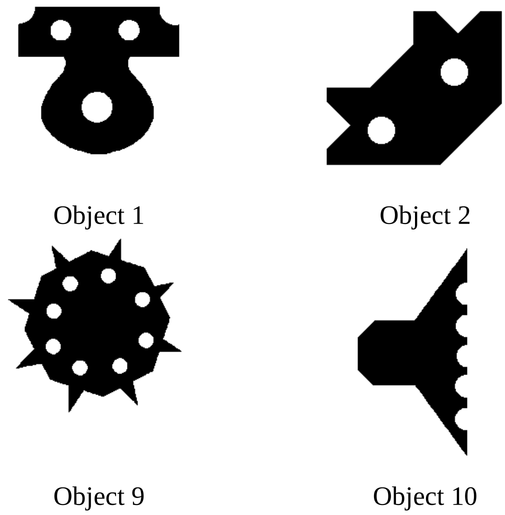


Fig. 1 – Examples of bitmaps of test objects

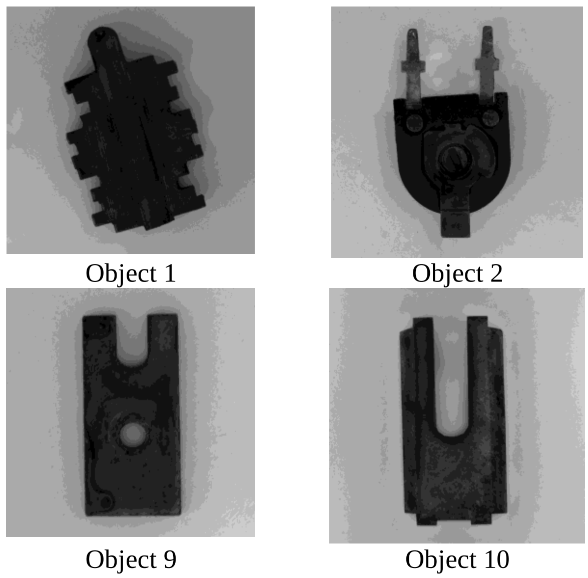


Fig. 2 – Examples of images of real objects

Further previously for each class of initial objects are formed selection of 360 turned images by turn around the center of mass with a step to 1 degree. Real grayscale images pass previously a nonlinear filtration and binared.

The center of mass of object is set by coordinates (x_c, y_c) defined as average value of coordinates (x, y), belonging to object.

Imitation of random separate object in sight of the recognition system is carried out by means of the random number generators (RNG) with normal distribution of data at the exit of generators in the range from 0 to 1. An interval of change of the output data of RNGs from 0,364 to 0,720 (at the size of the image 512x512 and the working field in 1024x1024 points). The numbers received with RNGs are used as the coordinate of the new center of mass of images. Selecting in a random way the image received on the previous step, we displace him using the generated value of the new center of gravity. In total we receive 2000 images of each type of initial objects.

Using the array of images received on the previous step images of the imposed objects for 2000 for each of the 55th class of imposing are formed.

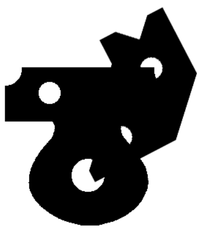
In the course of formation of the imposed images it is necessary to check really whether two images on the working field were imposed to exclude options of separately located objects. Such check is carried out with use algorithm of a recursive marking [8].

For only 55 classes of co-ordination we receive 110 000 images of imposed test (STFO) and real (SRFO) of flat objects.

Examples of STFO and SRFO of various classes are given in Fig. 3 and 4. Here for designation of a class of co-ordination two-symbolical designation where the number designates number of initial object from given on Fig 1 and 2 is used.

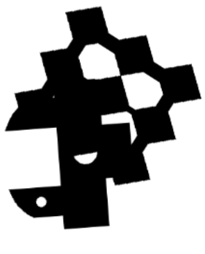
Further single-point contours of bitmaps of the imposed objects on algorithm in [1] are formed.

On the algorithm given in [5-7] on the basis of the received contours primary marks are calculated. Treat those: image P_0 perimeter length; area of the image S_0; quantity of points, with curvature of +90 (M_1),-90 (M_2), +135 (M_3) and-135 (M_4) degrees; metric length of a contour of $L_{kont.}$; total length of convex $L_{tot.Vyp.}$, concave $L_{tot.Vog.}$ and linear $L_{tot.Lin.}$ sites of all contour; quantity of 4 coherent points of a contour K; quantity of the D coherent points of a contour of T.



Class 1-2

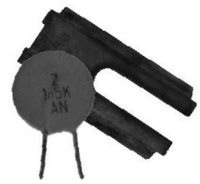
Class 10-10



Class 7-8

Class 5-6

Fig. 3 – Examples of the imposed images of various classes STFO



Class 7-10

Class 8-9

Class 4-5

Class 2-3

Fig. 4 – Examples of the imposed images of various classes SRFO

On the basis of the received primary marks vectors are formed the dimensionless marks on the formulas (1)-(16) given in [5-8]:

$K_1 = P_0 / S_0$	(1)	$K_2 = M_1 / S_0$	(2)
$K_3 = M_2 / S_0$	(3)	$K_4 = M_3 / S_0$	(4)
$K_5 = M_4 / S_0$	(5)	$K_6 = K / S_0$	(6)
$K_7 = T / S_0$	(7)	$K_8 = M_1 / P_0$	(8)
$K_9 = M_2 / P_0$	(9)	$K_{10} = M_3 / P_0$	(10)
$K_{11} = M_4 / P_0$	(11)	$K_{12} = K / P_0$	(12)
$K_{13} = S_0 / P_0$	(13)	$K_{14} = L_{tot.lin.}/L_{kont}$	(14)
$K_{15} = L_{tot.vog.}/L_{kont}$	(15)	$K_{16} = L_{tot.vyp.} /L_{kont}$	(16)

The following stage is training of system of technical sight. The algorithm of training consists in selection among the created 110 000 dimensionless vectors marks of reference vectors. Training of system is carried out separately on each of the 55th to a class. The received images of the imposed objects in each class can't be grouped in any sign. The imposing percent as the most obvious sign, can't be used in this case as to the same value of percent of imposing there can correspond various relative positioning of the objects used when forming the image of STFO, or SRFO. Therefore the choice of standards for recognition of a class of imposing is carried out as follows. Among 2000 vectors signs of one class the vector is chosen in a random way. We will accept this vector as reference in we consider a class.

For this vector marks by a method of the next distance [1], the algorithm of definition of a mean square deviation is calculated on (17) Z_i with each of 2000 vectors marks of this class.

$$Z_i = \frac{1}{n+1}\sum_{j=1}^{n}(K_j - K_{jl})^2, \quad (17)$$

where n – number of marks, l – number of the recognizable object (l = 1,2,…, 110 000), K_j – j-th value of a mark of a vector of coefficients K the chosen standard, K_{jl} – j-th value of a mark of a vector of coefficients K the chosen realization.

2000 distance Z_i are calculated. Among them Z_{min} on a formula (18) are looked for:

$$Z_{min} = \min\{ Zi \}, \quad (18)$$

If the founded Z_{min} value indicates a vector marks of the image of the same class, then this image is considered the recognizable current etalon and its vector marks is excluded from further consideration.

It is obvious that one etalon it is impossible to recognize all 2000 realization of one class.

If Z_{min} value indicates a vector marks of other class, then we pass to the choice of the following etalon for this class.

After all 2000 images of the considered imposing class are excluded, training of TSS in recognition of this class of co-ordination is finished.

The specified steps with use of formulas (17) and (18) repeat for all remained classes STFO or SRFO.

The quantity of the etalons chosen in the course of training for each class STFO and SRFO providing 100 percentage recognition of objects of the class is given in table 1 and 2.

Table 1. Quantity of the chosen etalons for each class STFO.

№	Combinations of objects	Quantity of etalons
1	1+1	918
2	1+2	940
3	1+3	892
…	…	…
53	9+9	730
54	9+10	710
55	10+10	630

Table 2. Quantity of the chosen etalons for each class SRFO.

№	Combinations of objects	Quantity of etalons
1	1+1	870
2	1+2	965
3	1+3	873
…	…	…
53	9+9	745
54	9+10	712
55	10+10	690

The following step carries out examination of the trained system on 110 000 realization of all 55 classes STFO or SRFO on the basis of formulas (17) and (18). Examination consists in comparison of vectors marks of all 110 000 realization 55 STFO or SRFO with the chosen etalons.

The choice of some casual object is made. For him all described procedures of receiving dimensionless marks of a contour are carried out. The received vector marks of an unknown class of imposing is compared to all received earlier reference vectors marks. The STFO or SRFO type according to min{Zmin} is defined. If the got number of a class doesn't coincide with known, the mistake is fixed.

Procedure of examination repeats for the 2nd unknown object and so on for all 110 000 realization of all 55 STFO or SRFO.

The table and plot of the correct recognition is under construction.

Dependence of probability of recognition of everyone a class from 55 STFO and SRFO from quantity of etalons is presented in tables 3 and 4.

Table 3. Quantity of the chosen standards for each class STFO.

Class	100	505	970
1+1	0,14	0,59	1
1+2	0,16	0,57	1
1+3	0,11	0,53	1
…	…	…	…
9+9	0,22	0,73	1
9+10	0,17	0,71	1
10+10	0,21	0,89	1

Table 4. Quantity of the chosen standards for each class SRFO.

Class	100	525	980
1+1	0,12	0,55	1
1+2	0,13	0,51	1
1+3	0,11	0,59	1
…	…	…	…
9+9	0,19	0,71	1
9+10	0,15	0,75	1
10+10	0,24	0,82	1

3. CONCLUSION

The used method of recognition has allowed to provide full identification of all STFO and SRFO. Depending on complexity of contours of the objects used at generation of various classes of the imposed objects equal unit needed various quantity of etalons for ensuring probability of recognition. The greatest number of etalons was required for the images received by imposing of the objects having difficult contour. Partial overlapping of a contour of one object by another complicates recognition.

At the same time, identification of the objects significantly differing from others requires smaller quantity of etalons. Respectively such objects and in the state imposed on itself significantly differ from other classes.

As a result of the conducted researches it is revealed that all classes of the imposed images can be completely identified.

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