DEFINITION OF ORIENTATION OF OBJECTS BY THE SYSTEMS OF TECHNICAL VISION

Rahim Mammadov[1], Timur Aliyev[2]

Azerbaijan State Oil Academy, Baku, Azerbaijan
[1]*rahim1951@mail.ru*, [2]*alievtima18@rambler.ru*

Recently scientists began to pay more attention to the problems of computer processing of the visual information. These problems are caused by quantity of the practical tasks taking place in different fields of science and technics. Moreover, the given problems contact directly with processing of images in the real world by the systems of technical vision (STV). The STV can work in the conditions of fast change of objects when the volume and speed of receipt of the information exceed the limits of physical possibilities of the person. These systems allow to process, analyse and compare the great volume of the information quickly, objectively and reliably enough. The influence of such factors as physical weariness of the person and value judgment [1,2] is excluded.

At recognition of images of objects arise the certain difficulties connected with their linear changes: the: turn of image round its centre of gravity, change of location in a co-ordinate plane [1,2]. It leads to loss of the information about number, place and absolute value of signs characterizing the object that complicates its analysis. Thus the definition of orientation of objects is an actual task.

Now for the definition of orientation of objects the STV make the normalization of their signs at any rule (e.g.: as a normalizing sign is taken the greatest or the least value) with their subsequent element-by-element comparison with reference signs or simple exhaustive search of every possible positions of objects with the subsequent direct comparison with reference object. However, in the first case there can be some identical normalizing signs in object, and the second case demands certain time that complicates the analysis of dynamic objects.

For the definition of the orientation of objects different methods and means [3,4] were offered. However the given methods cannot provide high efficiency because in the given works the basic emphasis was made on the statistical moments of objects which were considered as their basic signs. The analysis of the specified works has shown that signs, in this case, are too integrated, but efficiency is low.

In the given work it is offered to use the statistical moments as image reference points, and leaning against the given principle to develop an effective method of the definition of orientation of objects.

The axial moments, the centrifugal moments of images and the angle of rotation of axes of the turned object concerning the starting position are connected amongst themselves by formulas:

$$J_{X2} = J_{X1}\cos^2\alpha + J_{Y1}\sin^2\alpha + J_{X1Y1}\sin 2\alpha \tag{1}$$

$$J_{Y2} = J_{X1}\sin^2\alpha + J_{Y1}\cos^2\alpha - J_{X1Y1}\sin 2\alpha \tag{2}$$

$$J_{X2Y2} = J_{X1Y1}\cos 2\alpha + \frac{J_{X1} - J_{Y1}}{2}\sin 2\alpha \tag{3}$$

where: J_{X1}, J_{Y1}, J_{X1Y1} and J_{X2}, J_{Y2}, J_{X2Y2} are the according, axial and centrifugal moments of images of the initial and turned positions of object.

Because in formulas (1) $\div$ (3) the angle of rotation α is considered as positive by anti-clockwise turning of axes, so the positive angle of rotation of the object will be considered as clock-wise rotation.

The value of angle α can be calculated in four ways:

Way 1: Bringing the trigonometrical equation (1) into homogeneous one we receive the value of α:

$$\alpha_1 = \operatorname{arctg}\frac{\pm\sqrt{J_{X1Y1}{}^2 - (J_{Y1} - J_{X2})*(J_{X1} - J_{X2})} + J_{X1Y1}}{J_{Y1} - J_{X2}} - \pi * n;\ n = 0, 1. \qquad (4)$$

The equation (4) has its decision if:

A. The radicand is more than zero:

$$J_{X1Y1}{}^2 - (J_{Y1} - J_{X2})*(J_{X1} - J_{X2}) \geq 0$$

B. The fraction denominator is not equal to zero:

$$J_{Y1} \neq J_{X2}$$

Way 2: Bringing the trigonometrical equation (2) into homogeneous one we receive the value of α:

$$\alpha_2 = \operatorname{arctg}\frac{\pm\sqrt{J_{X1Y1}{}^2 - (J_{X1} - J_{Y2})*(J_{Y1} - J_{Y2})} - J_{X1Y1}}{J_{X1} - J_{Y2}} - \pi * n;\ n = 0, 1. \qquad (5)$$

The equation (5) has its decision if:

A. The radicand is more than zero:

$$J_{X1Y1}{}^2 - (J_{X1} - J_{Y2})*(J_{Y1} - J_{Y2}) \geq 0$$

B. The fraction denominator is not equal to zero:

$$J_{X1} \neq J_{Y2}$$

Way 3: Subtracting from the expression (1) the expression (2) we receive the value of α:

$$\alpha_3 = \pm\frac{1}{2}\arcsin\frac{J_{X2} - J_{Y2}}{\sqrt{(J_{X1} - J_{Y1})^2 + 4J_{X1Y1}{}^2}} - \frac{1}{2}\operatorname{arctg}\frac{J_{X1} - J_{Y1}}{-2J_{X1Y1}} - \frac{\pi}{2} * m;\ m = 0,1,2,3. \qquad (6)$$

The equation (6) has its decision if:

A. The value arcsin is within the limits of [1; 1]:

$$-\sqrt{(J_{X1} - J_{Y1})^2 + 4J_{X1Y1}{}^2} \leq J_{X2} - J_{Y2} \leq \sqrt{(J_{X1} - J_{Y1})^2 + 4J_{X1Y1}{}^2}$$

B. The denominator of the first fraction is not equal to zero:

$$(J_{X1} - J_{Y1})^2 + 4J_{X1Y1}{}^2 > 0$$

C. The denominator of the second fraction is not equal to zero:

$$J_{X1Y1} \neq 0$$

Way 4: Solving the equation (3) we receive the value of α:

$$\alpha_4 = \pm\frac{1}{2}\arcsin\frac{J_{X2Y2}}{\sqrt{J_{X1Y1}{}^2 + \left(\frac{J_{X1} - J_{Y1}}{2}\right)^2}} - \frac{1}{2} * \left|\operatorname{arctg}\frac{2 * J_{X1Y1}}{J_{X1} - J_{Y1}}\right| - \frac{\pi}{2} * m;\ m=0,1,2,3. \qquad (7)$$

The equation (7) has its decision if:

A. The value arcsin is within the limits of [1; 1]:

$$-\sqrt{J_{X1Y1}{}^2 + \left(\frac{J_{X1} - J_{Y1}}{2}\right)^2} \leq J_{X2Y2} \leq \sqrt{J_{X1Y1}{}^2 + \left(\frac{J_{X1} - J_{Y1}}{2}\right)^2}$$

B. The denominator of the first fraction is not equal to zero:

$$J_{X1Y1}{}^2 + \left(\frac{J_{X1} - J_{Y1}}{2}\right)^2 > 0$$

C. The denominator of the second fraction is not equal to zero:

$$J_{X1} \neq J_{Y1}$$

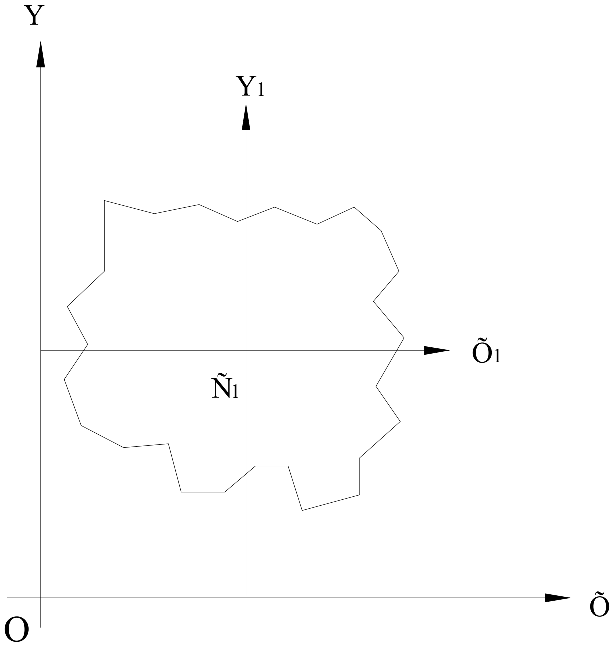

Fig. 1. The image of reference object.

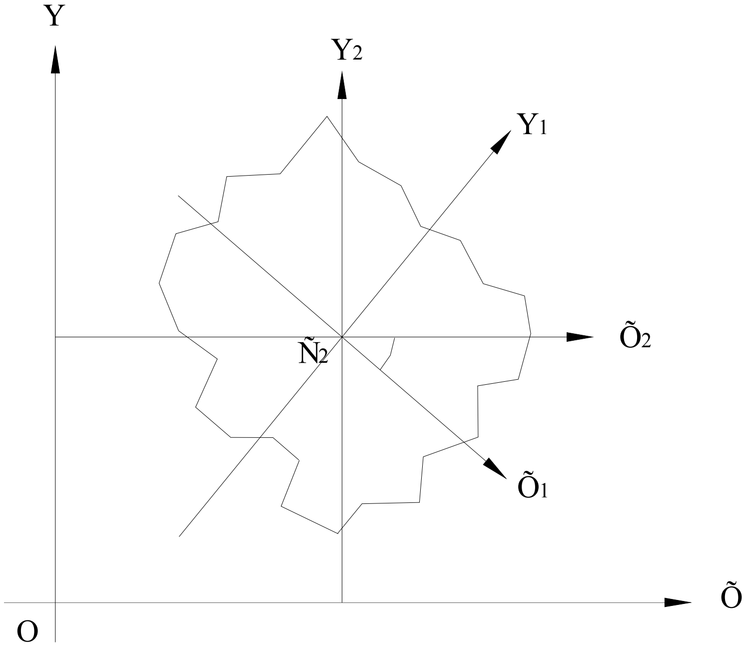

Fig. 2. The image of recognized object.

In the received formulas the read-out of α-angel is made clock-wise. It is visible from formulas that the calculations on the first and the second ways give four values of the angle of rotation α, and on the third and the fourth ways give – eight values of this one.

The offered method was simulated on the computer. For its check, as examples there were considered objects presented on fig. 1 and fig. 2 where as a recognized object the reference object turned concerning its starting position on angle $\alpha = 40^\circ$ in clock-wise rotation was taken. The initial data of the objects are Cartesion co-ordinates of their central points (files A1 A1($X1_i$, $Y1_i$) and A2($X2_j$, $Y2_j$)).

At first the co-ordinates of centres of gravity of the images of objects (points C1 and C2), are defined on known co-ordinates of their central points stored in memory which are calculated as arithmetic-mean values of points of corresponding files. Further, the rectangular systems of co-ordinates X1C1Y1 and X2C2Y2, are drawn and the new co-ordinates of central points of both images, according to these systems of co-ordinates are calculated. Under known formulas [5] are J_{X1}, J_{Y1}, J_{X1Y1}, J_{X2}, J_{Y2} and J_{X2Y2} defined.

As a result of calculations following values of α have been received:
With formula (4): 288,8568; 108,8568; <u>40,0001</u>; 220,0001
With formula (5): 306,6295; 126,6295; <u>40,0043</u>; 220,0043
With formula (6): <u>40,0644</u>; 310,0644; 220,0644; 130,0644; 36,5694; 306,5694; 216,5694; 126,5694
With formula (7): 18,8568; 288,8568; 198,8568; 108,8568; 310,0001; 220,0001; 130,0001; <u>40,0001</u>

From results of calculations it is visible that on each way the angle α of 40° has been received.

The presented method of the definition of orientation of the objects allows to define with high degree of reliability an angle of rotation of objects of any form concerning reference position making the minimum of calculations.

References

1. R. Gozalez, R. Woods. Digital image processing. (In Russian) "Tehnosfera" Publishing House, Moscow (2006) 1072 p.
2. L. Shapiro, G. Stockman. Computer vision. . (In Russian) "BINOM " Publishing House, Moscow (2006).
3. Mamedov R. G. Correction of estimation errors of the measure of affinity between objects at recognition patterns for intellectual systems./ "Problems of cybernetics and informatics", – Baku, Azerbaijan, 2006, pp. 21-24.
4. Mamedov R.G. Simulation of error estimation of the measure of proximity between objects in pattern recognition // Engineering Simulation, Overseas Publishers Association, USA,1999, Vol. 17, pp. 49- 57.
5. Feodosyev V. I. Strength of materials. "Nauka" Publishing House, Moscow (1974) 559 p. (In Russian)