Optical-electronic pattern recognition system based on the image's logarithmic chord transformation method

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ABSTRACT

A new kind of the image representation - logarithmic hord transformation of the images (LHTI) is suggested. A structures of an optical-electronic processor, performing operation of LHTI and of an image processing computer system are developed. The analytical estimation of time expenditures in the system is evaluated.

Keywords: image, hord, transformation, complexity, classification, invariancy, correlation, processor, computer system.

INTRODUCTION

At the decision of problems of flying vehicles control there is necessity in the high-speed computing means for invariant image processing.

In this article a new problem-oriented computer system is presented, the architecture of which is controlled by parameters of the input images. The system is based on logarithmic hord transformation of the images and the statistical analysis at a stage of objects classification.

In section 1 a new kind of the image representation - logarithmic hord transformation of the images (LHTI) is suggested. The feature of such representation consists in achievement of invariancy to shifts, orientation and scale of the input image, that permits essentially to reduce the volume of computing operations at a stage of objects classification. A structure of an optical-electronic processor, performing operation of LHTI is developed.

On the basis of the proposed method of LHTI and realizing its processor, a structure of an optical-electronic computer system is described (section 2). In the system the organization of adaptive processing of the information depending on complexity of the input images at stages of classification and of the images coordinates transformation is realized. In section 3 analytical estimation of time expenditures is evaluated in the developed system.

1. THE LOGARITHMIC HORD TRANSFORMATION OF THE IMAGE AND ITS REALIZATION

The logarithmic hord transformation of the image is defined as follows. Let $P_b(x,y)$ - is a binary contoured image of an object. For each pair of points on an external contour of object is constructed a hord and logarithm of its length r, $L_x=\ln(r)$, as well as angle Ψ between it and axis **x** are determined.

In such case the object can be characterized by the function $H(L_x,\Psi)$, describing by all possible hords. The representation of image $P_b(x,y)$ in a kind of function $H(L_x,\Psi)$ is the logarithmic hord transformation.

We shall consider an opportunity of realization of the LHTI operation. The values of function $P_b(x,y)$ in boundary points on the image of object are defined as: $P_b(x,y)=1$.

In such case hord will exist between two points of the image, if these points are on the boundary, i.e.

$$g(x,y,L_x,\Psi) = P_b(x,y)P_b[x+\ln(r\cos\Psi),y+\ln(r\sin\Psi)] = 1.$$

At various values of points combinations on a external contour of object we shall receive:

$$H(L_x\cos\Psi,L_x\sin\Psi)=\int\int g(x,y,L_x,\Psi)dxdy= =\int\int P_b(x,y)P_b(x+L_x\cos\Psi,y+L_x\sin\Psi)dxdy \quad (1)$$

The functions of lengths hord L_x density and angles Ψ can be determined as follows:

$$H(L_x)=\int_0^{\pi}\int\int g(x,y,L_x,\Psi)dxdyd\Psi, \quad H(\Psi)=\int_0^{L_x}\int\int g(x,y,L_x,\Psi)dxdydL_x.$$

At the change of angular orientation of object the function of density $H(\Psi)$ is reduced to shift, however the function of density $H(L_x)$ does not change. And on the contrary, at change of scale of object does not change the function $H(\Psi)$, and the function $H(L_x)$ displaces.

Distinctive feature of proposed method of hord transformation of images from known one[1] is an opportunity to transform the change of scale of the image to shift. It is reached by logarithming of hord lengths.

As will be shown later in section 3, the offered approach permits essentially to reduce the volume of computing expenditures at a stage of objects classification.

The direct realization of expression (1) will require large time expenditures. In this connection an other method of LHTI realization is of resonable expedient. In conformity to this method we shall define the function: $H(r\cos\Psi,r\sin\Psi)=\int\int P_b(x,y)P_b(x+r\cos\Psi,y+r\sin\Psi)dxdy$, or after substitution of $\xi=r\cos(\Psi)$, $\eta=r\sin(\Psi)$:

$$H(\xi,\eta)=\int\int P_b(x,y)P_b(x+\xi,y+\eta)dxdy=P_b(x,y)\star P_b(x,y) \quad (2)$$

The expression (2) represents autocorrelation function of the contoured image. The logarithmic hord transformation will be realized by representation of function $H(\xi,\eta)$ in a logarithmic polar coordinates system: $H(L_x,\Psi)=CT\{H(\xi,\eta)\}$, where CT - operation of image coordinates transformation; $L_x=\ln[(\xi^2+\eta^2)^{1/2}]$, $\Psi=\mathrm{arctg}(\xi/\eta)$.

As follows from expression (2), one of the LHTI stages is the calculation of autocorrelation function of the contoured binary image. As far as the optical processors will easily realize the function correlation, the optical realization of hord's transformation is rather attractive. At the same time in a optical processor without the incre-