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Recognition of separate flat objects based on dimensionless signs of their contours by linear discriminant analysis

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Abstract

The aim is an experimental research on the flat objects recognition by linear discriminant analysis, using dimensionless signs of the contours of their binary images and determining the possibility of applying this method in computer vision systems.

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Keywords: vision system; image recognition; flat object; details; dimensionless marks; linear discriminant analysis

1. Introduction

One of the ways of increasing the efficiency of production is to automate the process. This is connected with the use of robotic centers. Currently, these are the automatic systems of sorting, quality control, and packaging components[1-4].

Objects recognition assumes an object assignment to one of their predefined types. An operation of sorting components in the development of information processing algorithms in computer vision systems (CVS) can be stated as the problem of image recognition, perceived by the video camera of a system. For this purpose, the received images are processed and analyzed[3,4].

In[1, 4, 5, 8], algorithms and the system of recognition of separate, superimposed test and real-world flat objects with only one characteristic of their binary images' contours — the values of the curvature of points of the discrete contour — are designed.

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Since the curvature of discrete curve is not a invariant one to change scale of the objects in the system view, the use of a single sign for recognition the flat components leads to difficulties in the selection of standards[4–13].

This article describes the experimental study of the algorithm of separate test and real-world objects recognition on the dimensionless features of the contours of their binary images based on linear discriminant analysis[13]. The method of forming dimensionless signs is given in[5]. Applicable signs, and there are 20, are invariants to rotation, transfer, and change the scale of objects in the field of CVS.

2. An algorithm of recognition

The method of linear discriminant analysis, considered in this paper, suggests a preliminary calculation of function of the normal distribution density for each of the classes of recognizable images' details.

The basis for the classification of the object as object of known class is the highest value of the object density function of a normal distribution among all classes. The vector of average values, entering into the formula of the density function of the normal distribution, and the variance-covariance matrix for each training class are measured in the original data at the stage of CVS training. It is assumed that the calculated covariance matrices for different classes are considered different[13].

The density function of the normal distribution has the form:

$$f(x) = ((2\pi)^{\frac{p}{2}} \, |C|^{\frac{1}{2}})^{-1} e^{-\frac{1}{2}(x-m)^T C^{-1}(x-m)}, \tag{1}$$

where C – covariance matrix calculated by the formula:

$$c_{ij} = (n_k - 1)^{-1} \sum_{a=1}^{n_k} (x_{ia} - x_{icp})(x_{ja} - x_{jcp}) \quad , \tag{2}$$

where n_k is a number of observations in k class; x_{ja} is a value of j discriminant variable (value of j variable of a observation); x_{jcp} is an average value of i variable; m is a vector of variables' average values, p – number of discriminant variables.

The investigated object belongs to the k class if the density function f_k takes the greatest value among all the membership functions when substituted the object's parameter in the function f_k .

3. Experimental studies

The technology by conducting experiments is the preparation of a plurality of objects implementations, forming the vectors of dimensionless signs for each image, the selection of the training sequence, and the recognition of all objects, getting on the system input.

In the course of experimental studies, the occasional appearance of the object in the field of the camera of computer vision system was simulated. A presentational sampling of 2,000 images of each class is formed for each class of considered test generated and real-world objects images. Carrying out of experimental research includes the following steps[7]: the selection of a singleton object contour, the calculation of the primary characteristics, and the formation of the dimensionless vector signs. Halftone images undergo additionally preliminary nonlinear filtering and binarization by the Otsu's method.

Images of the original separate test flat objects (STFO) and the separate real-world flat objects (SRFO) used in the experiments are shown in Fig. 1a and Fig.1b, respectively.