Optical-electronic moments features-based recognition system controlled by parameters of the input images

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ABSTRACT

The new methods of invariant pattern recognition (IPR), based on the effective calculation of image moment features are presented. It is described the special purpose multiprocessor computer system, which realizes the proposed methods of IPR. The system is reconfigurable, with the architecture controlled by parameters of the input images.

Keywords: image, moment features, recognition, computer system

1. INTRODUCTION

One of the perspective directions in the invariant pattern recognition (IPR) represents the usage of the image's moment features (IMF). Such features are invariant to the position, the angular orientation, the scale change and the contrast of the input images. The IPR systems, based on IMF, can be used in missiles control[1,2], in radar image analyses[3], in computer vision[4] of different destinations and in other applications.

The calculation of IMF by traditional computer means requires essential time expenses, that impedes the realization of a real time mode. Therefore, for a successful usage of IMF at pattern recognition, the development of effective methods and means for calculation of the geometrical, central and normalized IMF are of great significance.

The high-productive structures of optical processors were developed for geometrical IMF calculation[1]. Such processors are simple and permit to generate the all values of geometrical IMF in one step. For the calculation of central and normalized IMF, the powerful digital post-processing will be required.

In this article are presented new methods of invariant pattern recognition on the basis of IMF (Sec.2). The methods permit to extract the required volume of information from the initial image and to process it in dependence with the complexity of the analyzed image, able to reorganize computing processes and to form central, as well as normalized IMF, depending on possible changes of scale, shifts, angular orientation of the objects.

In Section 3 is described a new special purpose optical electronic computer system for IPR on the basis of IMF. This system realizes proposed methods and is based on the principle of the architecture reconfiguration, controlled by the parameters of the input images[5]. The elaborated system is a re-configurable functional-distributed multiprocessor computer system. The possibility of architecture reconfiguration is provided by the operative reorganization of communications between different processors, and synchronization of their functioning. The communications are established in the system by the help of the distributed commutator units, placed in different blokes, and the special commutator matrix. Adjustment of the system and synchronization of its functioning is performed by controlling computer.

The results of the time expenditures estimation in the system are presented in section 4.

2. METHODS OF THE INVARIANT PATTERN RECOGNITION ON THE BASIS OF THE MOMENT FEATURES ADAPTIVE CALCULATION

There are elaborated 3 methods of invariant pattern recognition, based on IMF. The methods permit to extract the required volume of information from the initial image and to process it depending on the complexity of the analyzed image, able to reorganize computing processes and to form geometrical, central, normalized and invariant IMF depending on possible changes of scale, shifts, angular orientation of the objects.

Suppose that the distorted image is described by the function: $P(x',y') = DF\{P(x,y)\}$, where $P(x,y)$ - reference image, DF - operator of distortion, and

$$P(x',y') = P(x, y, e_1, e_2, e_3, e_4),$$

were e_1 – object scale change; e_2 – angular orientation change; e_3, e_4 – displacements of the object on the coordinates x and y.

2.1. The method of the pattern recognition on the basis of the geometrical IMF classification

The method of the pattern recognition on the basis of the geometrical IMF classification includes the next stages.

1. At the first stage the complexity IC of the input image $P(x',y')$ is calculated, and the necessary number of pixels DE=NxM to be processed is determined. The data IC, DE are used for required information extraction from the image on the stages of geometrical IMF formations and images normalization.

2. Depending on the parameter IC value, the required volume of information is extracted from the image $P(x',y')$, that needs to be processed:

$$P(x',y') \rightarrow P_R(x_1',y_1'),$$

were $x'=1\div N$, $y'=1\div M$, $x_1'=1\div K$, $y_1'=1\div L$, and $x_1'=f_1(IC)$, $y_1'=f_2(IC)$.

3. The geometrical IMF of the image $P_R(x_1',y_1')$ are calculated:

$$m'_{pq}= \iint (x_1')^p(y_1')^q P_R(x_1',y_1')dx_1dy_1 \tag{1}$$

4. The parameters of the object displacements e_3, e_4 are calculated on the basis of the geometrical IMF:

$$e_3=m'_{10}/m'_{00},$$
$$e_4=m'_{01}/m'_{00}.$$

5. A set of central IMF is calculated:

$$\mu'_{11} = m'_{11} - e_4\, m'_{10},$$
$$\mu'_{20} = m'_{20} - e_3\, m'_{10},$$
$$\mu'_{02} = m'_{02} - e_4\, m'_{01}.$$

6. The object's angular orientation is calculated:

$$e_2=[\mathrm{arctg}\{2\mu'_{11}/(\mu'_{20}-\mu'_{02})\}]/2.$$

7. The parameter of image scale e_1 is determined (by spatial equipment).

8. On the basis of parameters $e_1 \div e_4$ values and depending on the image complexity IC, the normalization of the image $P_R(x_1',y_1')$ is executed: