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CLASSIFICATION OF IMAGES BASED ON DISTANCE ASSESSMENT

Abstract. A method of image classification based on the estimation of the distance to the etalon class is proposed. The introduction of estimates provides a significant gain in classification speed compared to linear search while maintaining a decent level of accuracy. The methodology is based on the use of the triangle inequality for images given by a set of binary vectors - descriptors of the key points of the image.

Keywords: classification of images; keypoint descriptor; distance estimation; speed of classification.

The intensive development of computer vision systems requires the creation and research of new effective methods of intellectual analysis and processing of multidimensional data [1, 2]. Due to the significant volumes of multidimensional data analyzed and processed in computer vision, the task of more efficient use of computing resources by admissible reduction of costs for class determination or recognition of visual objects becomes urgent. This can be achieved by transitioning to a new modified data structure by transforming the existing space of features to simplify processing and ensure the necessary speed with a sufficient level of classification effectiveness [3-6].

In structural methods of image classification, the description Z of a visual object is given in the form of a finite set $Z = \{Z_v\}_{v=1}^{S}$ of S key point descriptors (KP). A descriptor Z_v is a numerical vector of dimension n. The description of the object and etalons is a finite set of multidimensional vectors.

Let the set $E = \bigcup_{i=1}^{N} E_i$ of etalon base be given as a union of N descriptions, recognized classes. In fact, E is the aggregate set of vectors-descriptors of the composition of all etalons, $E = \{E_i\}_{i=1}^{N} = \left\{\{e_v(i)\}_{v=1}^{S}\right\}_{i=1}^{N}$, where i is the class number, v is the current number of the element within the class, and S is the fixed number of descriptors in each of the etalons.

The traditional formulation of the problem of image classification by description in the form of a set of descriptors of key points leads to determining the relevance degree of two sets of multidimensional vectors and optimizing this criterion on the available set of etalons [5, 6].

The research aims to develop means of reducing calculations when implementing the rule $z \to [1,2,\ldots,N]$ of classifying an arbitrary vector $z \in Z$ into one of N classes by calculating the distance ρ from the object element $z \in Z$ to the class E_i by estimating the distance ρ with full use of the available information and classification conditions, under which the descriptions of the etalons E_i are sets of numerical vectors and are considered given a priori [4].

In the study, the applied aspects of the technical implementation of the proposed method were studied. Let $e^*(i) \in E_i$ be some fixed point of the set E_i. Let's consider a point $d(i) \in E_i^*$ belonging to the set $E_i^* = E_i / e^*(i)$ with an exception $e^*(i)$. Then the distance $a_i = \rho(z, d(i))$ from the point z of the object to the point $d(i)$ of the set can be estimated, based on the triangle inequality, through the calculated distance $b_i = \rho(z, e^*(i))$ and the predetermined distance $c_i = \rho(d(i), e^*(i))$ [2]:

$$\rho(d(i), e^*(i)) - \rho(z, e^*(i)) \le \rho(z, d(i)) \le \rho(d(i), e^*(i)) + \rho(z, e^*(i)). \quad (1)$$

Taking into account the need to obtain the most accurate estimate, which is determined by the shortest size of the interval in inequality (1), we obtain a double inequality:

$$c_{i,\max} - b_i \le \rho(z, E_i) \le c_{i,\min} + b_i, \quad (2)$$

where $c_{i,\min} = \min_{d(i) \in E_i^*} \rho(d(i), e^*(i))$, $c_{i,\max} = \max_{d(i) \in E_i^*} \rho(d(i), e^*(i))$.

We believe that it is acceptable to choose medoid [1] as the point $e^*(i)$ of the set with the minimum total distance to the rest of the points.

Components $c_{i,\min}$, $c_{i,\max}$ of the estimates (2) can be obtained directly at the stage of preliminary analysis of available etalon data, therefore, the volume of calculations in the classification process is not affected by their definition. To obtain the current estimate ρ, you only need to calculate the distance b_i from the query to the points $e^*(i) \in E_i$, $i = 1, \ldots, N$.

The Brisk descriptor based on the OpenCV library through the .NET 6 application and the Emgu.CV support package was used for simulation. An NFT image with a size of 540×540 pixels was selected as recognized objects [2].

The conducted experiment showed that the use of evaluation makes it possible not only to speed up the classification hundreds of times, but also to reveal in more detail the similarity of individual fragments of images on a set of classes.

The developed method of building an applied model of a classifier using evaluation demonstrates the simplification and acceleration of the process of determining the class of an image without a significant decrease in the classification accuracy [2].

The gain in classification time increases proportionally with the increase in the number of descriptors in the description. The application of descriptor-to-class distance estimation models has opened up new opportunities for in-depth detection of image details and multi-criteria classification decision making.

At the same time, we note that the choice of a specific method of classification acceleration for an arbitrary application set of etalons should be based on the experimental verification of the effectiveness of the methods.

The results of this research were obtained under the international research project INITIATE under the grant No. 101136775-HORIZON-WIDERA-2023-ACCESS-03.

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