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Visual duplicates image search for a non-cooperative person recognition at a distance

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Abstract

The project is aimed at developing new person recognition algorithm, which deals with the problems using matching of filtered histograms of oriented gradients computed in circular sliding windows and using inverted index of histograms for efficient image retrieval. The project results have various scientific, industry and social applications, which require automatic non-cooperative indoors and outdoors person recognition at a distance using multimodal biometrics extracted from multisensory noisy data. For instance, new security and surveillance systems working under in open weather could be developed based on the proposed methods. The performance of the proposed person recognition algorithm in the actual environment is presented and discussed. The results of computer simulation obtained with the proposed algorithm are compared to those of available algorithms in terms of matching accuracy and processing time.

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Keywords: face recognition, matching algorithm; local oriented gradient histogram; image search; inverted index; histogram analysis; vector-space metrics

1. Introduction

Research in biometric person recognition has recently received a notable attention due to a growing interest in development of new real-time automatic security and surveillance systems. Many of the biometric features that are highly distinctive and have permanence (such as fingerprints and iris) require a cooperative subject in close

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proximity to a biometric system. Existing reliable methods of active cooperative identification cannot be used for passive non-cooperative person recognition at a distance. Even under fully favorable conditions (controlled illumination, good image quality, sufficient resolution, frontal images, and neutral expression), the best algorithms of passive non-cooperative face recognition at a distance produce a high equal error rate, and thus, the performance is unlikely to be sufficient for most applications [1]. Therefore, it is extremely important to develop new non-cooperative methods for person recognition at a distance using multimodal biometrics extracted from multisensory noisy data that are robust to uncontrolled environment conditions. Methods of face recognition is one of the most rapidly developing area and they just might provide a basis for constructing a non-cooperative person authentication system. Face recognition systems use different methods for obtaining information: by a single image, by a video, by a three-dimensional image, by using infrared light. Many approaches have developed to allocate face at images or video streams. Once the face is localized, different techniques can be applied on the base of face appearance or face geometry [2]. Facial recognition technology can be global [3] and local [4], different processing methods based on 2D images and 3D face models. Face recognition systems based on 2D images possesses a drawback of sensitivity to light, effects of changing the face position. To compensate these effects, a 2D image is transformed to canonical position storage of facial images from different angles, and recognition uses generalized models of faces. The analysis of three dimensional data can help to overcome the drawbacks: using 3D image interpolation position can be reduced to turn restored 3D face model to a new position, and illumination affects only texture, while reconstruction of the surface retains its properties. Existing recognition methods can be classified as follows: global methods, statistical methods, parametric models. The most popular methods of face recognition are principal component analysis (PCA) [5] and linear discriminant analysis (LDA) [6], elastic graph models, local binary patterns, using 3D descriptors [7-8]. Recent methods of face recognition utilize 3D descriptors invariant to facial expressions, dynamic information, gait analysis and gestures. To achieve 3D face recognition, there are two parts devised: image matching and visual image search [9]. The most popular matching algorithms based on key points are SIFT (Scale Invariant Feature Transform) [10], SURF (Speeded-Up Robust Features) [11] and ORB (Oriented FAST and Rotated BRIEF) [12]. In the current research is considered image search method that uses features, which give an opportunity to detect near duplicates of given image examples by separation from the other images of the collection. The proposed method consists of the following stages: preprocessing, matching and image search. The paper is organized as follows. In Section 2, the proposed matching algorithm based on HOGs descriptor are presented. In Section 3, the visual duplicates image search is considered. In Section 4, using inverted index of histograms for effective image retrieval is considered. Computer simulation results are provided in Section 5. Section 6 summarizes our conclusions.

2. Matching algorithm based on HOGs Descriptor

In this topic a new fast matching algorithm based on recursive calculation of oriented gradient histograms over several circular sliding windows is presented [13]. Let us define a set of circular windows $\{W_i, i = 1, \ldots, M\}$ in a target fragment as a set of closed disks:

$$W_i = \left\{(x, y) \in R^2 : (x - x_i)^2 + (y - y_i)^2 \le r_i\right\} \quad (1)$$

where (x_i, y_i) are the coordinates of the center and r_i — is the radius of the disks. Numerous experiments have shown that the number of circular windows may be chosen from 2 to 4 to yield good matching performance. Histograms of oriented gradients are good descriptors for matching because they possess a high discriminant capability and robust to small image deformations such as rotation and scaling. The histograms are calculated over the sliding geometric structure. At each position of the *i-th* circular window on a frame fragment we compute gradients inside the window with the help of the Sobel operator. Next, using the gradient magnitudes $\{Mag_i (x, y) : (x, y) \in W_i\}$ and orientation values $\{\varphi_i (x, y) : (x, y) \in W_i\}$, quantized for Q levels, the histogram of oriented gradients can be computed as follows: