International Journal of Research
eISSN: 2348-6848 & pISSN: 2348-795X Vol-5 Special Issue-13
International Conference on Innovation and Research in Engineering, Science & Technology
Held on 23rd & 24th February 2018, Organized by Tulsiramji Gaikwad Patil College of Engineering & Technology, Nagpur, 441108, Maharastra, India.

"Robust Face Recognition Using Largest Matching Area for Illumination and Occlusion"

1st Akshata Bansod[1], 2nd Snehal Paliwar[2] & 3rd Nagma Sheikh[3]
[1]M.Tech Student
[2,3]Assistant Professor
[1,2,3]Electronics & Communication Engineering Department,
[1,2,3]Tulsiramji Gaikwad-Patil College of Engineering,
[1,2,3]Rashtrasanta Tukdoji Maharaj Nagpur University, Nagpur, India
akshatabansod.extc@gmail.com

Abstract:

While there has been an enormous amount of research on face recognition under pose/illumination/expression changes and image degradations, problems caused by occlusions attracted relatively less attention. Facial occlusions, due, for example, to sunglasses, hat/cap, scarf, and beard, can significantly deteriorate performances of face recognition systems in uncontrolled environments such as video surveillance. The goal of this paper is to explore face recognition in the presence of partial occlusions, with emphasis on real-world scenarios (e.g., sunglasses and scarf). In this paper, we propose an efficient approach which consists of first analyzing the presence of potential occlusion on a face and then conducting face recognition on the nonoccluded facial regions based on selective local Gabor binary patterns. Experiments demonstrate that the proposed method outperforms the state-of-the-art works including KLD-LGBPHS, S-LNMF, OA-LBP, and RSC. Furthermore, performances of the proposed approach are evaluated under illumination and extreme facial expression changes provide also significant results.

Keyword

Biometrics, Face recognition, Identification of person

1. Introduction

Face recognition [1], the least intrusive biometric technique in terms of acquisition, has been applied to a wide range of commercial and law enforcement applications. State-of-the-art face recognition systems perform with high accuracy under controlled environments, but performances drastically decrease in practical conditions such as video surveillance of crowded environments or large camera networks. The main problems are due to changes in facial expressions, illumination conditions, face pose variations, and presence of occlusions. With emphasis on real-world scenarios, in the last decade, problems related to pose/illumination/expression changes and image degradations have been widely investigated in the literature. In contrast, problems caused by occlusions received relatively less investigations, although facial occlusion is quite common in real-world applications especially when individuals are not cooperative with the system such as in video surveillance applications. Facial occlusions may occur for several intentional or undeliberate reasons (see Figure 1). For example, facial accessories like sunglasses, scarf, facial make-up, and hat/cap are quite common in daily life. Medical mask, hard hat, and helmet are required in many restricted environments (e.g., hospital and construction areas). Some other people do wear veils for religious convictions or cultural habits. In addition, facial occlusions are often related to several severe security issues. Football hooligans and ATM criminals tend to wear scarves and/or sunglasses to prevent their faces from being recognized. Bank robbers and shop thieves usually wear a cap when entering places where they commit illegal actions.

Figure1: Illustration of different types of facial occlusions: (a) ordinary facial occlusions in daily life.

International Journal of Research
eISSN: 2348-6848 & pISSN: 2348-795X Vol-5 Special Issue-13
International Conference on Innovation and Research in Engineering, Science & Technology
Held on 23rd & 24th February 2018, Organized by Tulsiramji Gaikwad Patil College of Engineering & Technology, Nagpur, 441108, Maharastra, India.

Figure 1: (b) facial occlusions related to severe security issues (ATM crimes, football hooligans, etc.).

Because partial occlusions can greatly change the original appearance of a face image, it can significantly deteriorate performances of classical face recognition systems (such as [2–4], since the face representations are thus largely distorted). To control partial occlusion is a critical issue to achieve robust face recognition. Most of the literature works [5–17] focus on finding corruption-tolerant features or classifiers to reduce the effect of partial occlusions in face representation. However, information from the occluded parts can still hinder the recognition performance. Recently, researchers demonstrated that prior knowledge about the occlusion (e.g., type, location, and size) can be used to exclude the information from occluded parts, so as to greatly improve the recognition rate. Hence, explicit occlusion analysis is an important step in occlusion-robust face recognition. In this paper, we propose an occlusion analysis method to improve local Gabor binary pattern based face recognition [11], which outperforms literature works including [15].

The proposed approach consists of first detecting and segmenting occluded parts (e.g., sunglasses/scarves) and then applying face recognition on the nonoccluded facial regions. To do so, the presence of occlusion is first analysed in the patch-level using Gabor wavelets, PCA and SVM. Then we segment the occluded part more precisely from the other facial regions by a generalized Potts model Markov random field (GPM-MRF) [22]. This allows us to identify the presence of occlusion at the pixel-level so as to preserve as much as possible face information for the recognition. After the computation of an occlusion mask indicating which pixel in a face image is occluded, we propose a variant of local Gabor binary pattern histogram sequences (LGBPHS) [11] to efficiently represent occluded faces by excluding features extracted from the occluded pixels. Finally, we compared our approach with traditional approaches [2, 4, 11], our previous results [21], and state-of-the-art methods [13, 19, 20] on AR face database [23] and obtained the best results. Our experiments also suggested that, in comparison with weighting based method [20], occlusion exclusion (i.e., weighting as 0 or 1) is more appropriate to handle the occlusion problem in face recognition.

2. Related Work

The traditional methodology to address face recognition under occlusion is to find corruption-tolerant features or classifiers. Toward this goal, numerous previous works confirmed that locally emphasized algorithms are less sensitive to partial occlusions. Penev and Atick [5] proposed the local feature analysis (LFA) to extract local features by second order statistics. Martínez [6] proposed a probabilistic approach (AMM) which can compensate for partially occluded faces. Tan et al. [7] extended Martinez's work by using the self-organizing map (SOM) to learn the subspace instead of using the mixture of Gaussians. In [8], Kim et al. proposed a method named locally salient ICA (LS-ICA) which only employs locally salient information in constructing ICA basis. In [9], Fidler et al. presented a method which combines the reconstructive and discriminative models by constructing a basis containing the complete discriminative information. Park et al. [10] proposed to use a line feature based face attributed relational graph (ARG) model which encodes the whole geometric structure information and local features of a face. Zhang et al. [11] proposed a nonstatistical face representation—local gabor binary pattern histogram sequence (LGBPHS), to exploit the multiresolution and multiorientation Gabor decomposition. In [12], Jia and Martinez proposed the use of partial support vector machines (PSVM) in scenarios where occlusions may occur in both the training and testing sets.

In this paper, we consider the first case as occlusion exclusion and the later one as occlusion weighting (note that occlusion exclusion can be regarded as a special case of occlusion weighting, where the weights are either 0 or 1). Because many of the algorithms we have discussed so far will be extensively analysed and compared in the experiments section, we summarize and categorize the literature works in Table 1 (for which abbreviations will be used in later sections).

Category	Abbreviation	Full name/brief description
Locality emphasized features/classifier	LFA AMM ARG PSVM LS-ICA	Local feature analysis Gussian mixture modelling of part based eigenface Attribute relational graph Partial support vector machines Local sailent-independent copmponent analysis
SCR based method	SCR SIFT-SCR	Sparse representation based classification SIFT feature used in SRC

Table 1: Summary of literature works in occluded face recognition.

Based on our preliminary work [21], in this paper, we propose a complete and fully automatic framework to improve face recognition in the presence of partial occlusions. Besides the occlusion detection module (which was introduced in [21]) which can detect the presence of occlusion in patch-level, we adopted GPM-MRF to detect occlusion in pixel-level to facilitate later recognition. We then propose a customized corruption-tolerant local descriptor selective LGBPHS which summarizes features from nonoccluded pixels for efficient face representation and recognition. Unlike [11, 20], our approach applies occlusion exclusion (by assigning weights as 0 or 1) based on our explicit occlusion analysis. Our results demonstrate that occlusion exclusion is more efficient than occlusion weighting, since weighting based methods still preserve some information from the occluded region. In addition, because the proposed occlusion analysis is an independent module from the face matching part and no model learning step (such as Eigenface [2], Fisherface [3] or SRC [13]) is required in our approach, the proposed method is not limited by the number of training samples. As a consequence, unlike SRC based methods [13–17], the proposed approach can be applied to face recognition with very limited training samples.

3. Working of system

A comprehensive overview of the proposed system is given in Figure 2. Given a target (i.e., probe) face image (which can be occluded or not) to be recognized, the possible presence of occlusion is first analysed. The probe image is divided into a number of facial components for occlusion detection. Each component is individually analysed by an occlusion detection module. As a result, potential occluded facial components are identified. Then, an occlusion mask is generated by a more precise segmentation approach to supervise the feature extraction and matching process. Based on the resulting occlusion mask, its LGBPHS representation is computed using the features extracted from the nonoccluded region only, namely, selective LGBPHS. The recognition is performed by comparing the selective LGBPHS from the probe image against selective LGBPHS from the template images using the same occlusion mask. The nearest neighbour (NN) classifier and Chi-square distance are adopted for the recognition.

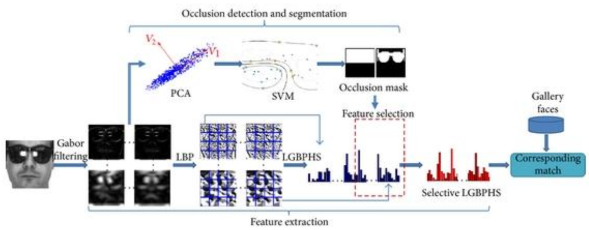

Figure2: System Flowchart

3.1. Occlusion Detection in Local Patches

As depicted in Figure 3, our occlusion detection starts by dividing the face image into different facial components. The number and the shape of the components are determined by the nature of the occlusion. Since our focus in this work is scarf and sunglasses, we accordingly divide the face images into two equal components as shown in Figure 3. The upper part is used for analysing the presence of sunglasses while the lower part is used for detecting scarf.

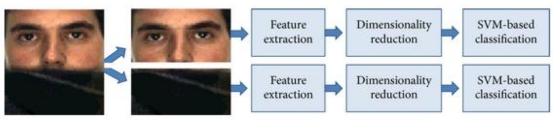

Figure3: Occlusion detection scheme

3.1.1. Gabor Wavelet Based Feature Extraction

Gabor wavelets are used for extracting features from the potentially occluded regions. The choice of using Gabor wavelets is motivated by their biological relevance, discriminative power, and computational properties.

3.1.2. Dimensionality Reduction Using PCA

Because the size of extracted Gabor feature is rather big, in order to reduce the dimension of the feature vectors while preserving its discriminative power, we apply principal component analysis (PCA) to maximize the variance in the projected subspace for the Gabor features. To compute the PCA subspace, we consider a training dataset consisting of feature vectors from both occluded and nonoccluded image patches.

3.1.3. SVM Based Occlusion Detection

Occlusion detection can be cast as a two-class classification problem. Since nonlinear support vector machines (SVM) are proven to be a powerful tool for discriminating 2 classes of high dimensional data, we adopted then a nonlinear SVM classifier for occlusion detection.

3.2. Occlusion Segmentation

In order to efficiently exploit the information of facial occlusion for face recognition, we generate a binary mask (1 for occluded pixels and 0 for nonoccluded pixels) indicating the location of occluded pixels to facilitate later feature extraction and matching in the recognition phase. This mask generation process is called occlusion segmentation. To generate an accurate occlusion mask (which can remove the occluded part meanwhile preserving as much as information from the nonoccluded part), we adopt a generalized Potts model Markov random field (GPM-MRF) [22] to enforce structural information (shape) of occlusion, so as to identify if a given pixel is occluded or not.

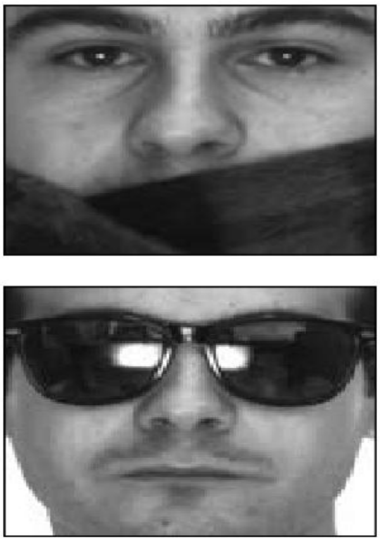

Figure 4: Illustration of our occlusion segmentation: examples of faces occluded by scarf and sunglasses.

3.3. Selective LGBPHS Based Face Representation and Recognition

To perform the recognition step, we propose a variant of LGBPHS [11] based face representation (namely, selective LGBPHS) which selects features from nonoccluded pixels only. The choice of using LGBPHS based representation is based on the following facts: it takes the advantage of both Gabor decomposition (multiresolution and multiorientation for enhanced discriminative power) [6] and LBP description (robustness to monotonic gray scale changes caused by, e.g., illumination variations) [4]; block-based histogram representation makes it robust to face misalignment and pose variations to some extent; it provides state-of-the-art results in representing and recognizing face patterns under occluded conditions [11, 20]; Gabor features in LGBPHS share the same computation as in our occlusion detection module.

4. Conclusion

We addressed the problem of face recognition under occlusions caused by scarves and sunglasses. Our proposed approach consisted of first conducting explicit occlusion analysis and then performing face recognition from the nonoccluded regions. The salient contributions of our present work are as follows: (i) a novel framework for improving the recognition of occluded faces is proposed; (ii) state-of-the-art in face recognition under occlusion is reviewed; (iii) a new approach to detect and segment occlusion is thoroughly described; (iv) extensive experimental analysis is conducted, demonstrating significant performance enhancement using the proposed approach compared to the state-of-the-art methods under various configurations including robustness against sunglasses, scarves, nonoccluded faces, screaming, and illumination changes. Although we focused on occlusions caused by sunglasses and scarves, our methodology can be directly extended to other sources of occlusion such as hats, beards, and long hairs. As a future work, it is of interest to extend our approach to address face recognition under general occlusions, including not only the most common ones like sunglasses and scarves but also beards, long hairs, caps, and extreme facial make-ups. Automatic face detection under severe occlusion, such as in video surveillance applications, is also far from being a solved problem and thus deserves thorough investigations.

5.References

[1] W. Zhao, R. Chellappa, P. J. Phillips, and A. Rosenfeld, "Face recognition: a literature survey,"ACM Computing Surveys, vol. 35, no. 4, pp. 399–458, 2003. View at Publisher · View at Google Scholar ·View at Scopus

[2] M. A. Turk and A. P. Pentland, "Face recognition using eigenfaces," in Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR '91), pp. 586–591, June 1991. View at Scopus

[3] P. N. Belhumeur, J. P. Hespanha, and D. J. Kriegman, "Eigenfaces vs. fisherfaces: recognition using class specific linear projection," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 19, no. 7, pp. 711–720, 1997. View at Publisher · View at Google Scholar ·View at Scopus

[4] T. Ahonen, A. Hadid, and M. Pietikäinen, "Face description with local binary patterns: application to face recognition," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, no. 12, pp. 2037–2041, 2006. View at Publisher · View at Google Scholar · View at Scopus

[5] P. S. Penev and J. J. Atick, "Local feature analysis: a general statistical theory for object representation," Network, vol. 7, no. 3, pp. 477–500, 1996. View at Google Scholar · View at Scopus

[6] A. M. Martínez, "Recognizing imprecisely localized, partially occluded, and expression variant faces from a single sample per class," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 24, no. 6, pp. 748–763, 2002. View at Publisher · View at Google Scholar · View at Scopus

[7]X. Tan, S. Chen, Z.-H. Zhou, and F. Zhang, "Recognizing partially occluded, expression variant faces from single training image per person with SOM and soft κ-NN ensemble," IEEE Transactions on Neural Networks, vol. 16, no. 4, pp. 875–886, 2005. View at Publisher ·View at Google Scholar · View at Scopus

[8]J. Kim, J. Choi, J. Yi, and M. Turk, "Effective representation using ICA for face recognition robust to local distortion and partial occlusion,"IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 27, no. 12, pp. 1977–1981, 2005.View at Publisher · View at Google Scholar · View at Scopus

[9]S. Fidler, D. Skočaj, and A. Leonardis, "Combining reconstructive and discriminative subspace methods for robust classification and regression by subsampling," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, no. 3, pp. 337–350, 2006. View at Publisher · View at Google Scholar · View at Scopus

[10]B.-G. Park, K.-M. Lee, and S.-U. Lee, "Face recognition using face-ARG matching," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 27, no. 12, pp. 1982–1988, 2005. View at Publisher· View at Google Scholar · View at Scopus

[11]W. Zhang, S. Shan, W. Gao, X. Chen, and H. Zhang, "Local Gabor Binary Pattern Histogram Sequence (LGBPHS): a novel non-statistical model for face representation and recognition," in Proceedings of the 10th IEEE International Conference on Computer Vision (ICCV '05), pp. 786–791, IEEE Computer Society, Washington, DC, USA, October 2005. View at Publisher · View at Google Scholar ·View at Scopus

[12]H. Jia and A. M. Martinez, "Support vector machines in face recognition with occlusions," inProceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops (CVPR '09), pp. 136–141, June 2009. View at Publisher · View at Google Scholar · View at Scopus

[13]J. Wright, A. Y. Yang, A. Ganesh, S. S. Sastry, and Y. Ma, "Robust face recognition via sparse representation," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 31, no. 2, pp. 210–227, 2009. View at Publisher · View at Google Scholar · View at Scopus

[14]Z. Zhou, A. Wagner, H. Mobahi, J. Wright, and Y. Ma, "Face recognition with contiguous occlusion using Markov Random Fields," in Proceedings of the 12th International Conference on Computer Vision (ICCV '09), pp. 1050–1057, October 2009. View at Publisher · View at Google Scholar ·View at Scopus

[15]M. Yang and L. Zhang, "Gabor feature based sparse representation for face recognition with gabor occlusion dictionary," in Proceedings of the 11th European conference on Computer vision (ECCV '10), pp. 448–461, Springer, Berlin, Germany, 2010.