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基于3D人脸重建的光照、姿态不变人脸识别

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Abstract
Pose and illumination changings from picture to picture are two main barriers toward full automatic face recognition. In this paper, a novel method to handle both pose and lighting conditions simultaneously is proposed, which calibrates the pose and lighting to a predefined reference condition through an illumination invariant 3D face reconstruction. First, some located facial landmarks and a priori statistical deformable 3D model are used to recover an elaborate 3D shape. Based on the recovered 3D shape, the "texture image" calibrated to a standard illumination is generated by spherical harmonics ratio image and finally the illumination independent 3D face is reconstructed completely. The proposed method combines the strength of statistical deformable model to describe the shape information and the compact representations of the illumination in spherical frequency space, and handles both the pose and illumination variation simultaneously. This algorithm can be used to synthesize virtual views of a given face image and enhance the performance of face recognition. Experimental results on CMU PIE database show that this method can significantly improve the accuracy of the existing face recognition method when pose and illumination are inconsistent between gallery and probe sets.

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摘要
待匹配人脸图像与库存原型图像之间姿态和光照的差异是自动人脸识别的两个主要瓶颈问题,已有的解决方法往往只能单独处理二者之一,而不能同时处理光照和姿态问题.提出了一种对人脸图像中的姿态和光照变化同时进行校正处理的方法,即通过光照不变的3D人脸重建过程,将姿态和光照都校正到预先定义的标准条件下.首先,利用先验的统计变形模型,结合人脸图像上的一些关键点来恢复较为精细的人脸3D形状.基于此重建的3D形状,进而通过球面谐波商图像的方法估计输入图像的光照属性并提取输入图像的光照无关的纹理信息,从而将光照无关的3D人脸完全重构出来,生成输入人脸图像在标准姿态和光照条件下的虚拟视图,用于最终的分类识别,实现了对光照和姿态问题的同时处理.在CMU PIE数据库上的实验结果表明,此方法可以在很大程度上提高现有人脸识别方法对于原型集合(gallery)和测试集合中图像在姿态和光照不一致情况下识别结果的正确性.

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References:

[1] Phillips PJ, Grother P, Micheals RJ, Blackburn DM, Tabassi E, Bone M. Face recognition vendor test 2002: Evaluation report. Technical Report, NISTIR 6965, Gaithersburg. National Institute of Standards and Technology, 2003.

[2] Turk M, Pentland A. Eigenfaces for recognition. Journal of Cognitive Neuroscience, 1991,3(1):71-86.

[3] Belhumeur PN, Hespanha JP, Kriegman DJ. Eigenfaces vs Fisherfaces: Recognition using class specific linear projection. IEEE Trans. on Pattern Analysis and Machine Intelligence, 1997,19(7):711-720.

[4] Gross R, Matthews I, Baker S. Eigen light-fields and face recognition across pose. In: Williams AD, ed. Proc. of the Conf. on FGR 2002. Washington: IEEE Computer Society, 2002. 3-9.

[5] Zhou S, Chellappa R. Illuminating light field: Image-Based face recognition across illuminations and poses. In: Azada D, ed. Proc. of the FGR 2004. Washington: IEEE Computer Society, 2004. 229-234.

[6] Georghiades AS, Belhumeur PN, Keiegman DJ. From few to many: Illuminition cone models for face recognition under variable lighting and poses. IEEE Trans. on Pattern Analysis and Machine Intelligence, 2001,23(6):643-660.

[7] Zhao W, Chellappa R. SFS based view synthesis for robust face recognition. In: Crowley JL, ed. Proc. of the FGR 2000. Washington: IEEE Computer Society, 2000. 285-292.

[8] Blanz V, Vetter T. Face recognition based on fitting a 3D morphable Model. IEEE Trans. on Pattern Analysis and Machine Intelligence, 2003,25(9):1063-1074.

[9] Chai X, Shan S, Gao W, Chen X. Example-Based learning for automatic face alignment. Journal of Software, 2005,16(5):718-726 (in Chinese with English abstract). http://www.jos.org.cn/1000-9825/16/718.htm

[10] Huang T, Lee C. Motion and structure from orthorgraphic projections. IEEE Trans. on Pattern Analysis and Machine Intelligence, 1989,11(5):536-540.

[11] Blanz V, Vetter T. A morphable model for the synthesis of 3D faces. In: Rockwood A, ed. Proc. of the SIGGRAPH'99. New York: ACM Press, 1999. 187-194.

[12] Qing L, Shan S, Gao W, Du B. Face recognition under generic illumination based on harmonic relighting. Int'l Journal of Pattern Recognition and Artificial Intelligence, 2005,19(4):513-531.

[13] Basria R, Jacobs D. Lambertian reflectance and linear subspaces. In: Bob W, ed. Proc. of the ICCV 2001. Washington: IEEE Computer Society, 2001. 383-390.

[14] Sim T, Baker S, Bsat M. The CMU pose, illumination, and expression (PIE) database. In: Williams AD, ed. Proc. of the Conf. on FGR 2002. Washington: IEEE Computer Society, 2002. 46-51.

[15] Liu C, Wechsler H. Gabor feature based classification using the enhanced fisher linear discriminant model for face recognition. IEEE Trans. on Image Processing, 2002,11(4):467-476.

[16] Gao W, Cao B, Shan S, Zhou D, Zhang X, Zhao D. The CAS-PEAL large-scale Chinese face dataBase and evaluation protocols. Technique Report, No.JDL-TR_04_FR_001, Beijing: Joint Research & Development Laboratory, the Chinese Academy of Sciences, 2004.

[17] Gross R, Mattews I, Baker S. Appearance-Based face recognition and light-fields. IEEE Trans. on Pattern Analysis and Machine Intelligence, 2004,26(4):449-465.

附中文参考文献:

[9] 柴秀娟,山世光,高文,陈熙霖.基于样例学习的面部特征自动标定算法.软件学报,2005,16(5):718-726. http://www.jos.org.cn/1000-9825/16/718.htm