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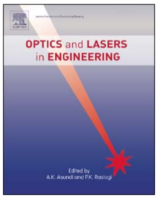

Designing a composite correlation filter based on iterative optimization of training images for distortion invariant face recognition

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ABSTRACT

We present a novel method to optimize the discrimination ability and noise robustness of composite filters. This method is based on the iterative preprocessing of training images which can extract boundary and detailed feature information of authentic training faces, thereby improving the peak-to-correlation energy (PCE) ratio of authentic faces and to be immune to intra-class variance and noise interference. By adding the training images directly, one can obtain a composite template with high discrimination ability and robustness for face recognition task. The proposed composite correlation filter does not involve any complicated mathematical analysis and computation which are often required in the design of correlation algorithms. Simulation tests have been conducted to check the effectiveness and feasibility of our proposal. Moreover, to assess robustness of composite filters using receiver operating characteristic (ROC) curves, we devise a new method to count the true positive and false positive rates for which the difference between PCE and threshold is involved.

1. Introduction

Since Vijiaya Kumar employed the minimum average correlation energy (MACE) filter for face verification [1], much effort has been done to perform distortion-invariant face recognition tasks under different environmental conditions using composite filters (CF) [2–8]. Compared with many conventional appearance (such as subspace representations) based recognition methods [9,10], CF based face recognition algorithms exhibit generally better discrimination ability and tolerance against expressional changes, noisy interference, and lighting fluctuations [11]. Moreover, owing to the shift-invariance property of CFs, such kinds of algorithms are able to perform classification and localization simultaneously without requiring any prior segmentation of objects in the tested scenes. In other words, correlation peaks produced by CFs appear at the locations where the authenticated objects are detected in the test scene.

Before presenting our scheme, it is necessary to give a brief review about some pioneering works dealing with CFs. The MACE [12], unconstrained MACE (UMACE) [13], and their extensions were among the earliest CFs [14–16] used for face recognition. In Ref. [1], the authors found that these CFs can offer good matching performance in presence of variance in the facial images, e.g., face expression and illumination changes. In another study [2], Wijaya et al. found that the optimal trade-off SDF (OTSDF) [17] can perform illumination-tolerant face verification of compressed target images at low bit rates due to its built-in noise robustness. A nonlinear variance of MACE, correntropy MACE (CMACE), was proposed in Ref. [14] where second- and higher-order moments of signal statistics are introduced to enhance the CMACE discrimination. Illumination invariant face recognition with the minimum noise and correlation energy filter (MINACE) is given in Ref. [15], for which satisfying performance criteria were achieved for both face identification and verification. In Ref. [18], several typical composite filters, including the MACE, UMACE, phase-only unconstrained MACE filter (POUMACE) [16], distance-classifier correlation filter (DCCF) [19], and minimum distance transform correlation filter (MDTCF) [20], are compared with standard learning methods and several face and head pose databases. The POUMACE filter provided the best performance with 100% accuracy for the facial expression database and the Yale frontal face illumination database [18]. Other significant schemes include Fernandez's zero-aliasing correlation filters (ZACF) that can reduce the wide sidelobe caused by circular correlations [7,21], and the maximum margin correlation filter (MMCF) based on the combination of support vector machine (SVM) and CF [22]. In spite of the impressive achievements achieved by CFs, the design of such filters often involves complicated mathematical analysis and computation in order to ensure high identification and certain robust-

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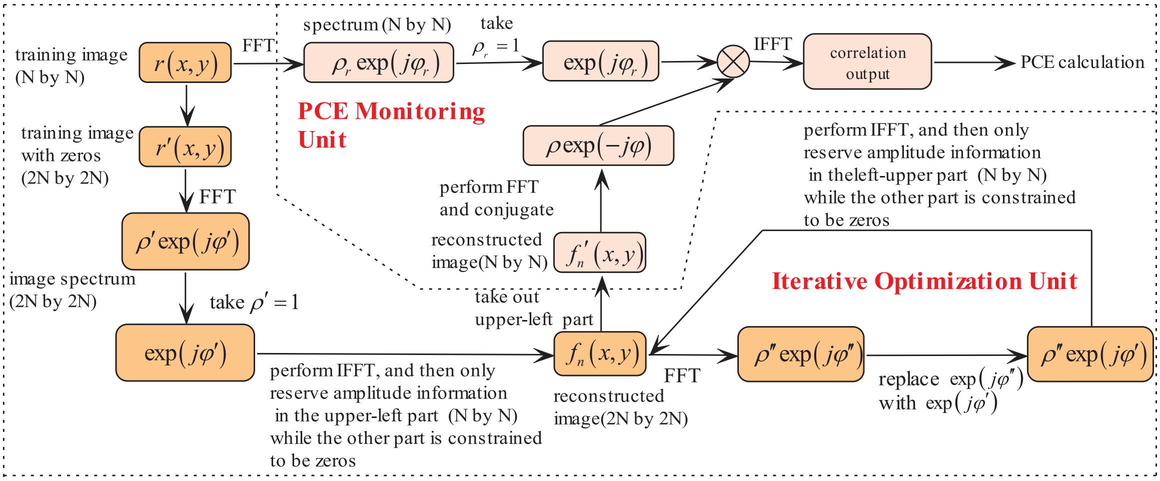

Fig. 1. Synoptic diagram of the proposed optimization algorithm.

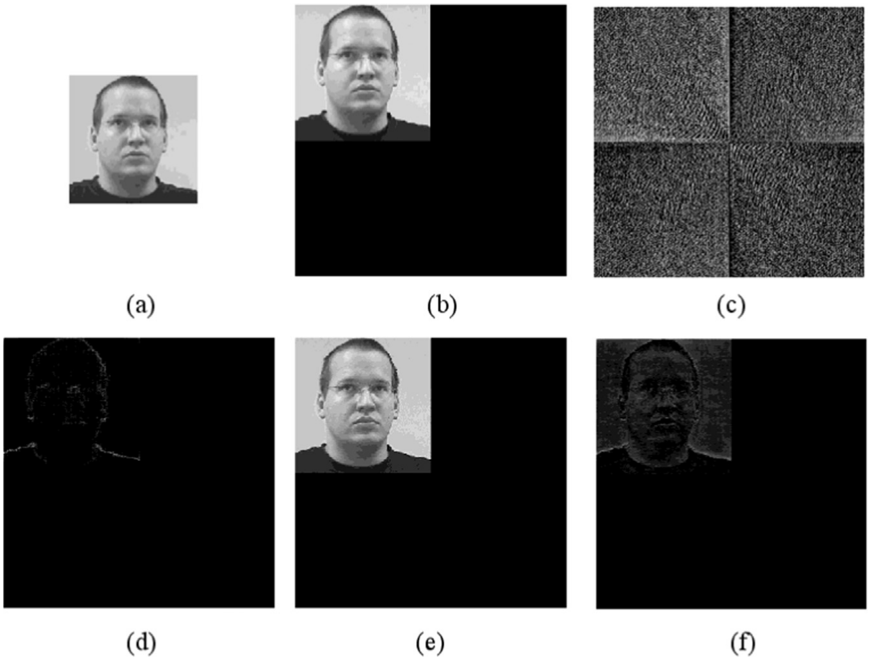

Fig. 2. (a) Original training image $r(x, y)$; (b) Extended training image embedded in zeros $r'(x, y)$; (c) Phase distribution $\exp(j\varphi')$; (d) Reconstructed image for the first iteration $f_1(x, y)$; (e) Reconstructed image after 200 iterations; (f) Reconstructed image after 3 iterations $f_3(x, y)$.

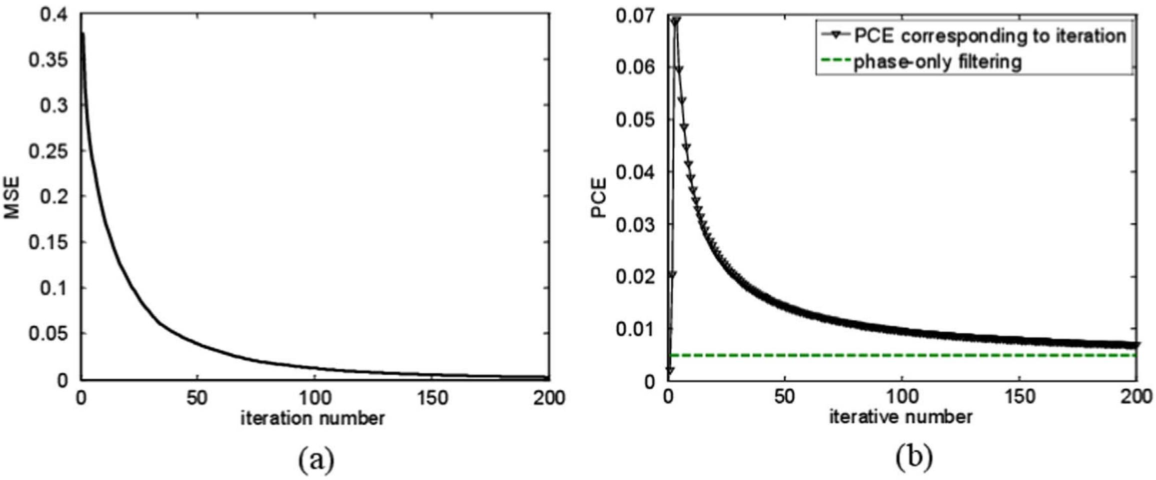

Fig. 3. (a) MSE and (b) PCE curves during the iterative optimization.