

## Supplemental Material for the paper “On Reducing the Effect of Covariate Factors in Gait Recognition: a Classifier Ensemble Method”

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In this supplemental document, we demonstrate the reconstructed GEIs corresponding to different features. Fig. 1 shows several original GEIs of the same subject from the USF dataset, including one gallery GEl in normal condition in Fig.1(a) and six probe GEIs with different covariates in Fig.1(b)-Fig.1(g). Although these GEIs are from the same subject, from the visual effect we can see that probe GEIs are different from the gallery GEl, owing to different walking conditions with covariates. For reconstruction experiments, first we train the 2DPCA space using the gallery set (of the USF dataset), which includes 122 subjects walking in normal condition. Then we conduct several reconstruction tasks:

- 1) In Fig. 2, we demonstrate the GEIs reconstructed using the features in the (traditional) 2DPCA subspace, which is spanned by the leading eigenvectors. We can see the reconstructed GEIs are similar to the ones in Fig. 1, which indicates the effectiveness of traditional 2DPCA in terms of reconstruction. However, compared with the gallery GEl in Fig.2(a), the probe GEIs in Fig.2(b)-Fig.2(g) still contain a significant amount of covariate information.
- 2) In Fig.3 - Fig.8, we show the reconstructed GEIs using the (enhanced) features in the 2DPCA subspace spanned by eigenvectors with different indices<sup>1</sup>. These eigenvectors may only preserve a small amount of the variance, resulting in low reconstruction accuracy, e.g., the reconstructed images shown in Fig. 7(a) corresponding to the 55<sup>th</sup> and 58<sup>th</sup> leading eigenvectors. However, the effect of covariates may also be reduced, which is important to gait classification. In Fig.3 - Fig.8, from the visual effect we can find high levels of similarity between the reconstructed gallery/probe GEl pairs.

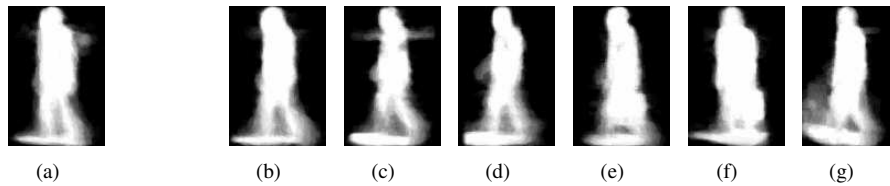


Fig. 1. The original GEIs of the same subject from the USF dataset. The leftmost (a) is gallery GEl in normal condition, while the rest (b)-(g) are probe GEIs with covariates (b) viewpoint, (c) walking surface, (d) viewpoint and walking surface, (e) carrying condition, (f) carrying condition and viewpoint, (g) elapsed time, shoe type, clothing, and walking surface

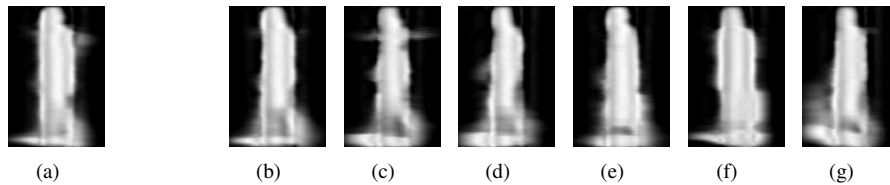


Fig. 2. The reconstructed GEIs (of Fig. 1) based on traditional 2DPCA with the leading 10 eigenvectors

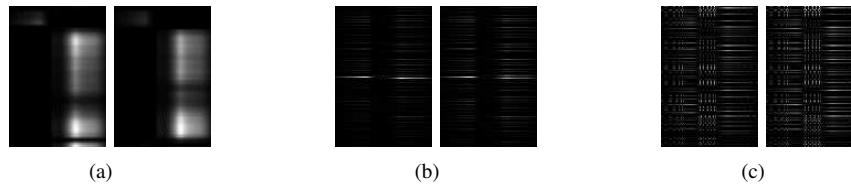


Fig. 3. Three reconstructed gallery/probe GEl pairs (of Fig.1(a)/Fig.1(b)) based on: (a) features in the 2DPCA subspace spanned by eigenvectors with indices [59,2] (b) enhanced features by LE1 in the 2DPCA subspace spanned by eigenvectors with indices [59,2] (c) enhanced features by LE2 in the 2DPCA subspace spanned by eigenvectors with indices [59,2]

<sup>1</sup>We only use the indices corresponding to subspaces with correct classification, i.e., yielding true votes in the classifier ensemble.

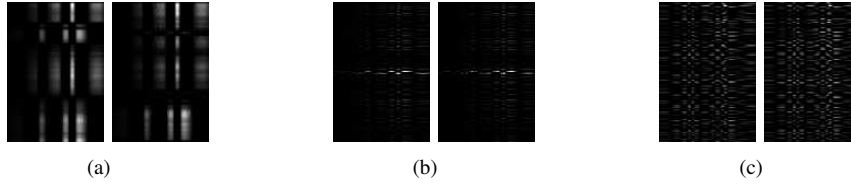


Fig. 4. Three reconstructed gallery/probe GEI pairs (of Fig.1(a)/Fig.1(c)) based on: (a) features in the 2DPCA subspace spanned by eigenvectors with indices [9,54] (b) enhanced features by LE1 in the 2DPCA subspace spanned by eigenvectors with indices [28,9] (c) enhanced features by LE2 in the 2DPCA subspace spanned by eigenvectors with indices [14,9]

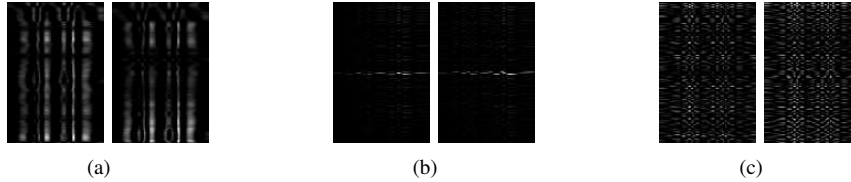


Fig. 5. Three reconstructed gallery/probe GEI pairs (of Fig.1(a)/Fig.1(d)) based on: (a) features in the 2DPCA subspace spanned by eigenvectors with indices [18,13] (b) enhanced features by LE1 in the 2DPCA subspace spanned by eigenvectors with indices [14,9] (c) enhanced features by LE2 in the 2DPCA subspace spanned by eigenvectors with indices [14,21]

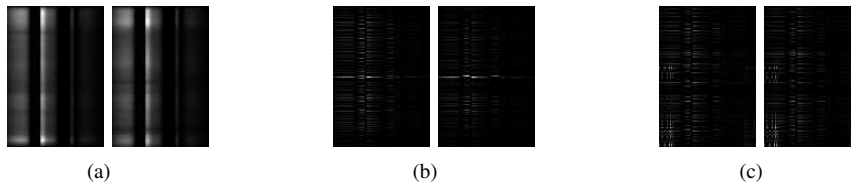


Fig. 6. Three reconstructed gallery/probe GEI pairs (of Fig.1(a)/Fig.1(e)) based on: (a) features in the 2DPCA subspace spanned by eigenvectors with indices [6,79] (b) enhanced features by LE1 in the 2DPCA subspace spanned by eigenvectors with indices [6,79] (c) enhanced features by LE2 in the 2DPCA subspace spanned by eigenvectors with indices [6,79]

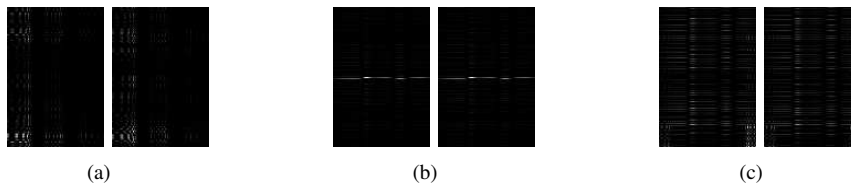


Fig. 7. Three reconstructed gallery/probe GEI pairs (of Fig.1(a)/Fig.1(f)) based on: (a) features in the 2DPCA subspace spanned by eigenvectors with indices [55,58] (b) enhanced features by LE1 in the 2DPCA subspace spanned by eigenvectors with indices [81,5] (c) enhanced features by LE2 in the 2DPCA subspace spanned by eigenvectors with indices [81,5]

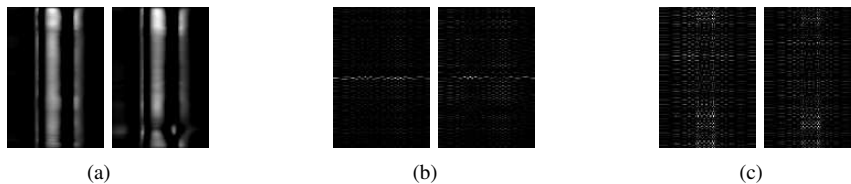


Fig. 8. Three reconstructed gallery/probe GEI pairs (of Fig.1(a)/Fig.1(g)) based on: (a) features in the 2DPCA subspace spanned by eigenvectors with indices [10,7] (b) enhanced features by LE1 in the 2DPCA subspace spanned by eigenvectors with indices [19,22] (c) enhanced features by LE2 in the 2DPCA subspace spanned by eigenvectors with indices [56,14]