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Learning Robust Features for Gait Recognition by Maximum Margin Criterion⋆ (Extended Abstract)

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In the field of gait recognition from motion capture (MoCap) data, designing human-interpretable gait features is a common practice of many fellow researchers. To refrain from ad-hoc schemes and to find maximally discriminative features we may need to explore beyond the limits of human interpretability. This paper contributes to the state-of-the-art with a machine learning approach for extracting robust gait features directly from raw joint coordinates. The features are learned by a modification of Linear Discriminant Analysis with Maximum Margin Criterion (MMC) so that the identities are maximally separated and, in combination with an appropriate classifier, used for gait recognition.

Recognition of a person involves capturing their raw walk sample, extracting gait features to compose a template that serves as the walker's signature, and finally querying a central database for a set of similar templates to report the most likely identity.

The goal of the MMC-based learning is to find a linear discriminant that maximizes the misclassification margin. We discriminate classes by projecting high-dimensional input data onto low-dimensional sub-spaces by linear transformations with the goal of maximizing the class separability. We are interested in finding an optimal feature space where a gait template is close to those of the same walker and far from those of different walkers. A solution to this optimization problem can be obtained by eigendecomposition of the between-class scatter matrix minus the within-class scatter matrix. Obtaining the eigenvectors involves a fast two-step algorithm in virtue of the Singular Value Decomposition. Similarity of two templates is expressed in the Mahalanobis distance.

Extensive simulations of the proposed method and eight state-of-the-art methods used a CMU MoCap sub-database of 54 walking subjects that performed 3,843 gait cycles in total, which makes an average of about 71 samples per subject. A variety of class-separability coefficients and classification metrics allows insights from different statistical perspectives. Results indicate that the proposed method is a leading concept for rank-based classifier systems: lowest Davies-Bouldin Index, highest Dunn Index, highest (and exclusively positive) Silhouette Coefficient, second highest Fisher's Discriminant Ratio and, combined with rank-based classifier, the best Cumulative Match Characteristic, False Accept Rate and False Reject Rate trade-off, Receiver Operating Characteristic (ROC) and recall-precision trade-off scores along with Correct Classification Rate, Equal Error Rate, Area Under ROC Curve and Mean Average Precision. We interpret the high scores as a sign of robustness. Apart from performance merits, the MMC method is also efficient: low-dimensional templates (dimension $\leq$ #classes$-1 = 53$) and Mahalanobis distance ensure fast distance computations and thus contribute to high scalability.

⋆ The full research paper **Learning Robust Features for Gait Recognition by Maximum Margin Criterion** has been accepted for publication at the 23rd International Conference on Pattern Recognition (ICPR 2016), Cancun, Mexico, December 2016. arXiv:1609.04392