Do I Know You? Optimizing the Facial Recognition System

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Introduction

Face recognition is the mechanism for a computer to determine whether a given face image is identifiable or unknown. Utilizing machine learning and computer vision techniques, computers can implement face recognition by matching new, unseen face images to a given set of trained images that the computer has already seen. Face recognition has been developing great interest as it is widely applicable to many areas including security, biometrics, and industry.

Data

The Morph II Database is a collection of 55,134 face images of 13,617 unique subjects. The 55,134 mugshots are from 2003 and 2008 and include images of individuals that were arrested once or multiple times. The size and longitudinal features of Morph II make it a widely used data source for computer vision and machine learning research.

Race and Gender Distribution of Morph II

	BLACK	WHITE	ASIAN	HISPANIC	OTHER	TOTAL
MALE	36,832	7,961	141	1,667	44	46,645
FEMALE	5,757	2,598	13	102	19	8,489
TOTAL	42,589	10,559	154	1,769	63	55,134

Sample Images

Cleaned Images

Background and Objective

Objective: Determine which combination of dimension reduction techniques and distance metrics will provide the greatest accuracy in the facial recognition task.

Background: Distance metrics are important quantitative tools for facial recognition. Every distance metric provides unique strengths but they all help determine whether two images are similar or not. When comparing two face images, each image's feature vector can be compared by utilizing distance metrics. The distances found after applying these distance metrics "between two vectors can be treated as a measure of dissimilarity of the two biometric samples" (Yassin)

Euclidean Distance

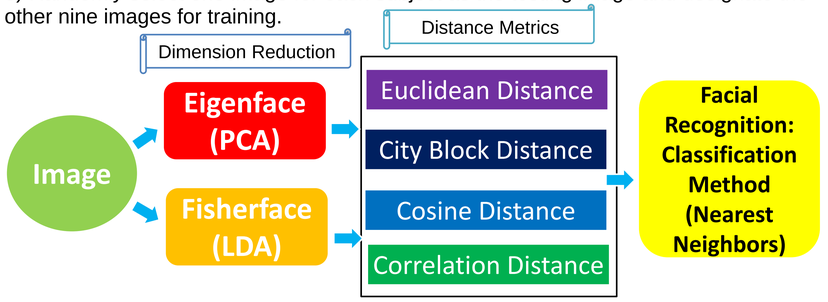
$$\mathrm{dist}(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

City Block Distance

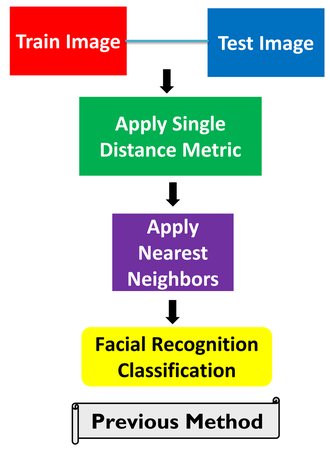
$$\mathrm{CBD}(x_i, x_j) = \sum_{k=1}^{m}\left|x_{ik} - x_{jk}\right|$$

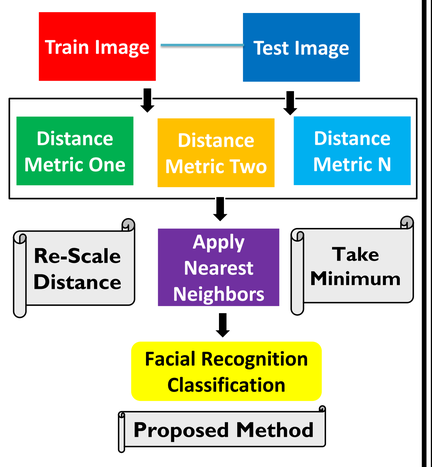
Experimental Design

Subset Scheme: 166 subjects with a total of 1,660 images, 83 Males and 83 Females
1) From the entire Morph II Database, develop a subset that only contains the images of subjects with ten or more images each.
2) Once the subset is created, randomly select ten images for each person.
3) Randomly select one image for each subject as the testing image and designate the other nine images for training.

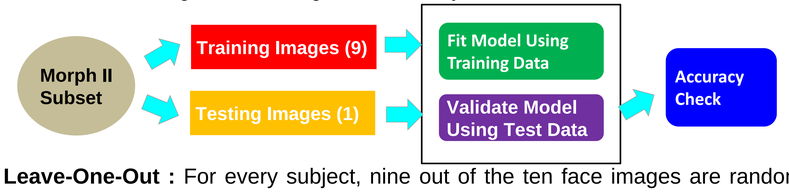


Project Layout: (1,494 Training Images and 166 Testing Images)
1) Obtain a feature vector from the face image.
2) Since the feature vector has too many dimensions, perform dimensionality reduction with 100 principal components using Principal Component Analysis (Eigenfaces) or Linear Discriminant Analysis (Fisherfaces).
3) After dimension reduction, apply the given distance metric between the two vectors.
4) Classify the test image as a subject from the training set utilizing nearest neighbors.





Decision Fusion: Using an Adaboost-like procedure, this study will apply multiple distance metrics with different weights to see if combining multiple weak distance metrics will result in a stronger facial recognition accuracy.



Leave-One-Out : For every subject, nine out of the ten face images are randomly assigned to training. The tenth image is then assigned to testing. Facial recognition accuracy is calculated once the test images are matched to a training image.

Results

Face Recognition Accuracy Under Different Distance Metrics

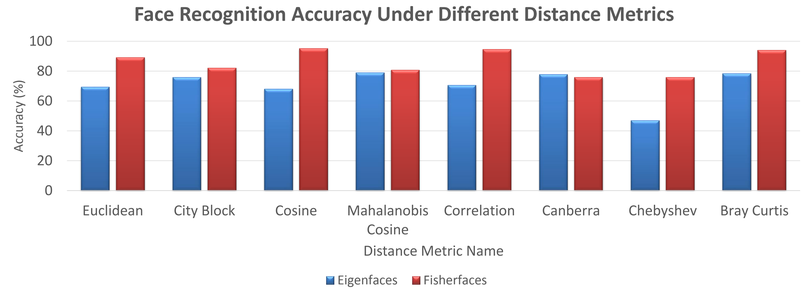
	Euclidean	City Block	Cosine	Mahalanobis Cosine	Correlation	Canberra	Chebyshev	Bray Curtis
Eigenface (PCA)	69.27%	75.90%	68.07%	78.91%	70.48%	77.71%	46.98%	78.31%
Fisherface (LDA)	89.15%	81.92%	95.18%	80.72%	94.57%	75.90%	75.90%	93.97%

Mahalanobis Distance

$$d_M(x,y) = \sqrt{(x-y)^T S^{-1}(x-y)}$$

Bray Curtis Distance

$$BC_d = \frac{\sum\left|x_i - x_j\right|}{\sum\left(x_i + x_j\right)}$$



Decision Fusion Table

	Weights	Weights	Weights
Cosine	0.9	0.95	1
Euclidean	0.1	0.05	1
Accuracy	69.87%	70.48%	68.67%

	Weights	Weights	Weights
Correlation	0.9	0.1	1
Euclidean	0.1	0.9	1
Accuracy	69.87%	71.08%	69.87%

Conclusion

- Under the Eigenfaces dimension reduction procedure, Mahalanobis Cosine Distance produced the greatest face recognition accuracy of 78.91%.
- Under the Fisherfaces dimension reduction procedure, Cosine distance produced the greatest face recognition accuracy of 95.18%.
- Decision fusion of weak distance metrics under Eigenfaces showed a minor improvement in face recognition accuracy. Future work can try more involved weighting schemes.

Reference

Yassin, Dk H. Phm, S. Hoque, and F. Deravi. "Age Sensitivity of Face Recognition Algorithms." 2013 Fourth International Conference on Emerging Security Technologies (2013): n. pag. Web.

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