

Assignment 1 SMAI

Lakshay Baijal 2024202006

Question 1 - PCA for Face Recognition and Video Calling

In this project, we tested a PCA-based face compression system to reduce the dimensionality of face images for real-time video calling. The approach involves three phases:

- **Phase-1:** Train PCA using a given face dataset (or a subset), compute the mean face, and extract eigenfaces.
- **Phase-2:** Visualize the eigenfaces and the quality of reconstructed faces via the reconstruction cost (MSE).
- **Phase-3:** Implement a video calling application where each side sends compressed PCA coefficients and reconstructs the face in real time.

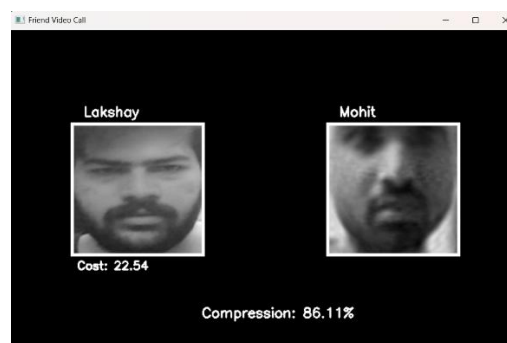


Fig – 1 PCA for face recognition with me and my friend

Task 1 –

https://drive.google.com/file/d/1t6KKGaGsws8Mw3zw2NCmQ7AhjegH1cay/view?usp=drive_link

Training Data: The entire dataset (both men and women)

- Under normal conditions, the reconstructed faces were reasonably clear.
- When part of the face was occluded or rotated, the reconstruction still captured the primary facial features, though the MSE increased.
- Typical MSE values ranged around 30 when the face was fully visible and slightly higher when occlusions were introduced.

Effectiveness: The PCA model trained on a diverse dataset generalized well under normal conditions.

Task 2 –

https://drive.google.com/file/d/1q_RwDMC7XZtI6iSh9ixrSqd4y6UKeT0O/view?usp=drive_link

Training Data: As a Male it was said to only train in Female Dataset.

- The reconstructed faces appeared noticeably degraded.
- Male facial features were not accurately captured, often resulting in blurred or feminized type face.
- MSE values were significantly higher around 55.

Mismatch Impact: Training exclusively on female faces leads the PCA basis to miss key variations in male facial features.

Task 3 –

https://drive.google.com/file/d/1BeCw7hc7xnUCHV8Yj8Tv5DapBXzKR8b6/view?usp=drive_link

Training Data: Only 500 images were randomly selected from the full dataset for PCA training.

- The quality of the reconstructed face was slightly reduced compared to using the full dataset.
- Minor artifacts appeared, especially under non-ideal conditions (such as slight head rotations).
- MSE values were marginally higher than in Task 1 around 60.
- The compression ratio was similar; however, the PCA basis captured less variability.

Trade-Off: The reduced training set leads to a trade-off between faster computation and lower reconstruction quality.

Task 4 –

https://drive.google.com/file/d/1QxNvTJQeF9OICNEJ81xlrSSB3q54R6zU/view?usp=drive_link

Training Data: The PCA was trained exclusively on images of my face and that of my friend.

- With my trained friend
 - The reconstructed face was highly accurate.
 - MSE was very low around 20 demonstrating excellent reconstruction.
- With my untrained friend
 - The reconstruction quality dropped dramatically, with distorted facial features.

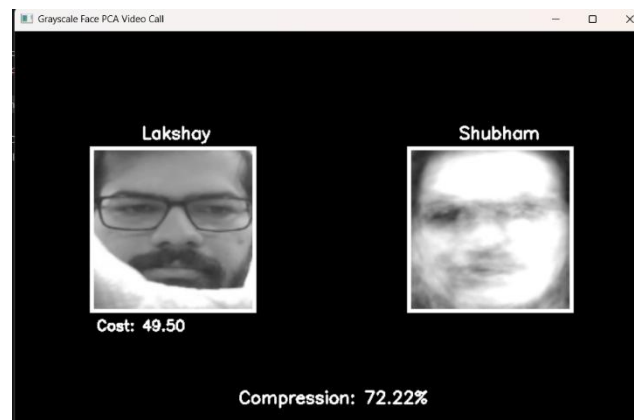


Fig – 2 Untrained Friends face

Specialization vs. Generalization: The PCA model, when trained on a very limited dataset it becomes highly specialized and performs exceptionally well for those specific faces. However, this specialization comes at the cost of generalizability to new faces.