Face Recognition

A comparison between Fisher Faces and PCA techniques

An implementation of
“Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection”
Belhumeur et al. 1997

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What are Fisher Faces?

A method that performs dimensionality reduction using linear projection and still retain linear separability of classes. It is a class specific projection method which chooses those set of projections which perform well over a range of varying lighting conditions, facial expressions and glasses for reconstruction. These set of projections are called Fisher Faces.

In contrast to the eigenfaces method, it uses those eigenvectors that maximise the ratio of inter-class to intra-class scatter. This tends to mask all the portions in the image that are highly variable (e.g. areas near mouth, for expressions).

Fig: EigenFaces visualized

Seem to focus on chunks of areas at a time irrespective of rate of variation in that area.

Eigenvalues decay and frequency content of images vary: initially low frequency and later on higher

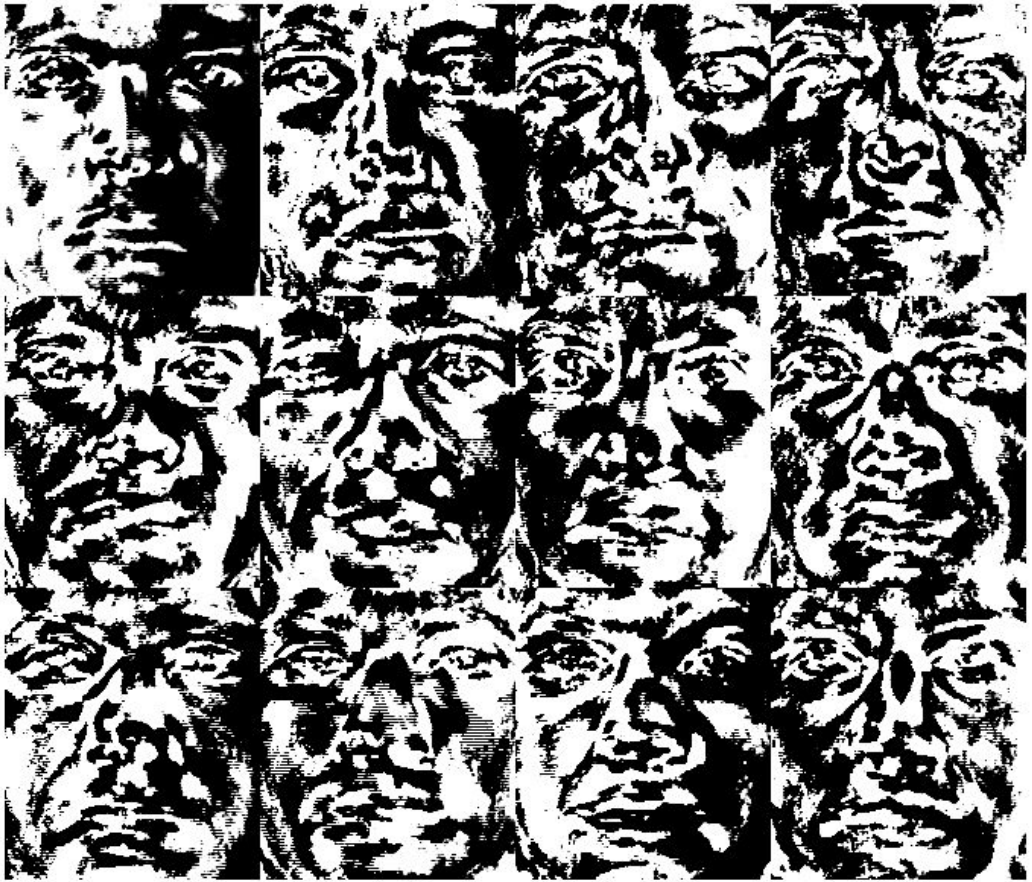


Fig: Fisher Faces visualized

Seem to focus on multiple areas at a time

The fact that the generalized eigenvalues show no decay (unlike PCA) is also reflected in these faces being similar in frequency content

Objective

The objective of the experiment was to determine which of the following two methods produce a lower amount of error rate w.r.t the number of Fisherfaces/Eigenfaces, when we perform the test on images that are variant in terms of facial expressions, light intensities, light source positions.

1) Principal components analysis (PCA) : - performs unbiased dimensionality reduction with respect to different classes. (both with and without rejecting the the first three eigenfaces).
2) Fisher's Linear Discriminant (FLD) :- performs the Fisherfaces method to generate reduced class specific eigenvectors.

Beyond the Paper

Experiment to verify the following claim

Claim : Whether reduced training for a particular person in a specific light setting leads to the test image with an untrained light setting being identified as another person with complete training.

Setup

Database used (excluding outer contours)	:	Cropped Yale database
Number of persons	:	38
Number of Samples per person	:	60 (each with different intensity and direction)
Reduced dimensions	:	varied from 50 - 400

FLD Equation

$$S_B . W_i = \lambda_i . S_W . W_i$$

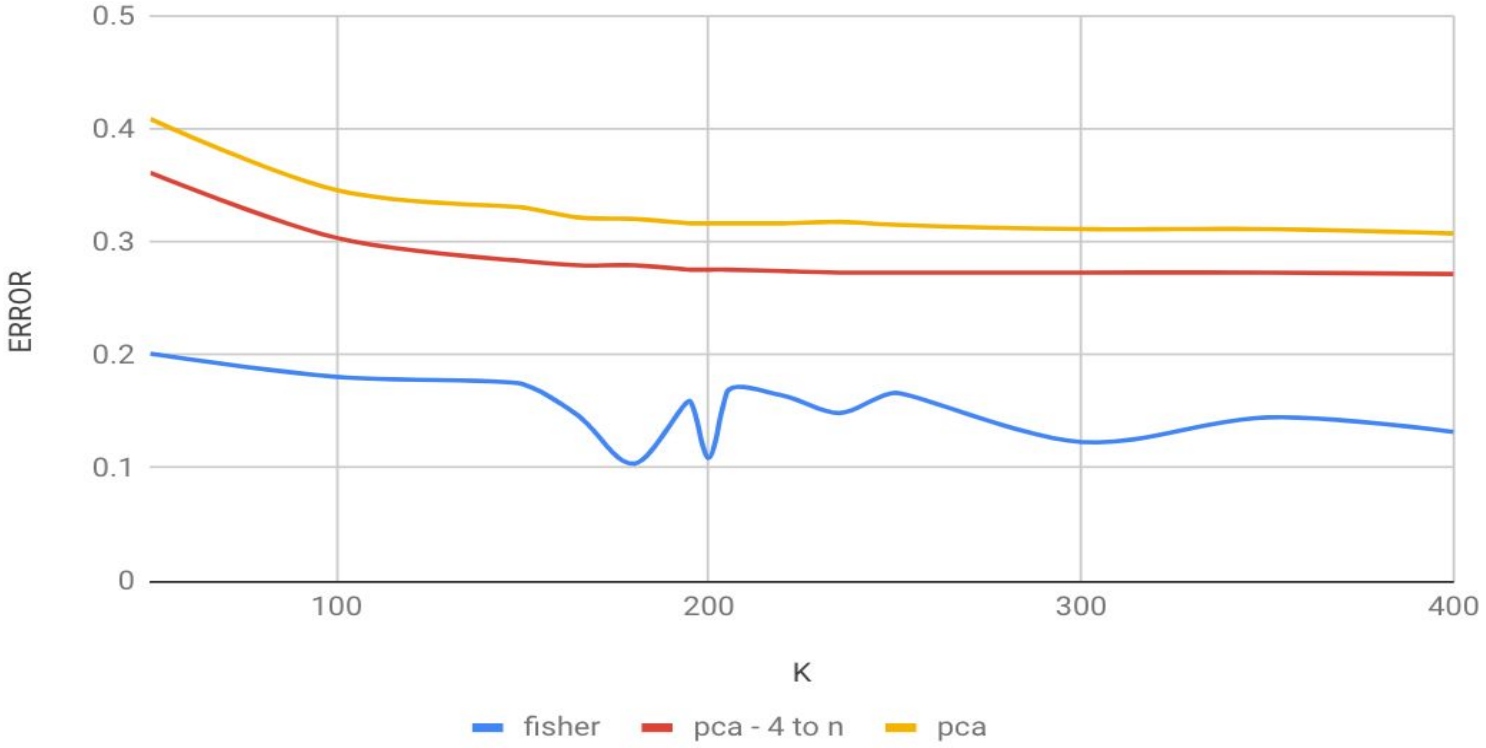
$$S_B = \Sigma_{i=1,c} N_i (\mu_i - \mu)(\mu_i - \mu)^* \text{.....between class scatter matrix}$$

$$S_W = \Sigma_{i=1,c} \Sigma_{X_k \in X_i} (X_k - \mu_i)(X_k - \mu_i)^* \text{.....within class scatter matrix}$$

$$W_{opt} = \arg\max_w (| W^* . S_B . W | / | W^* . S_W . W |)$$

$$\text{With PCA } = \arg\max_w (| W^* W_P^* . S_B . W_P W | / | W^* W_P^* . S_W . W_P W |)$$

Results



Experiment 1: Which cases are Misclassified?

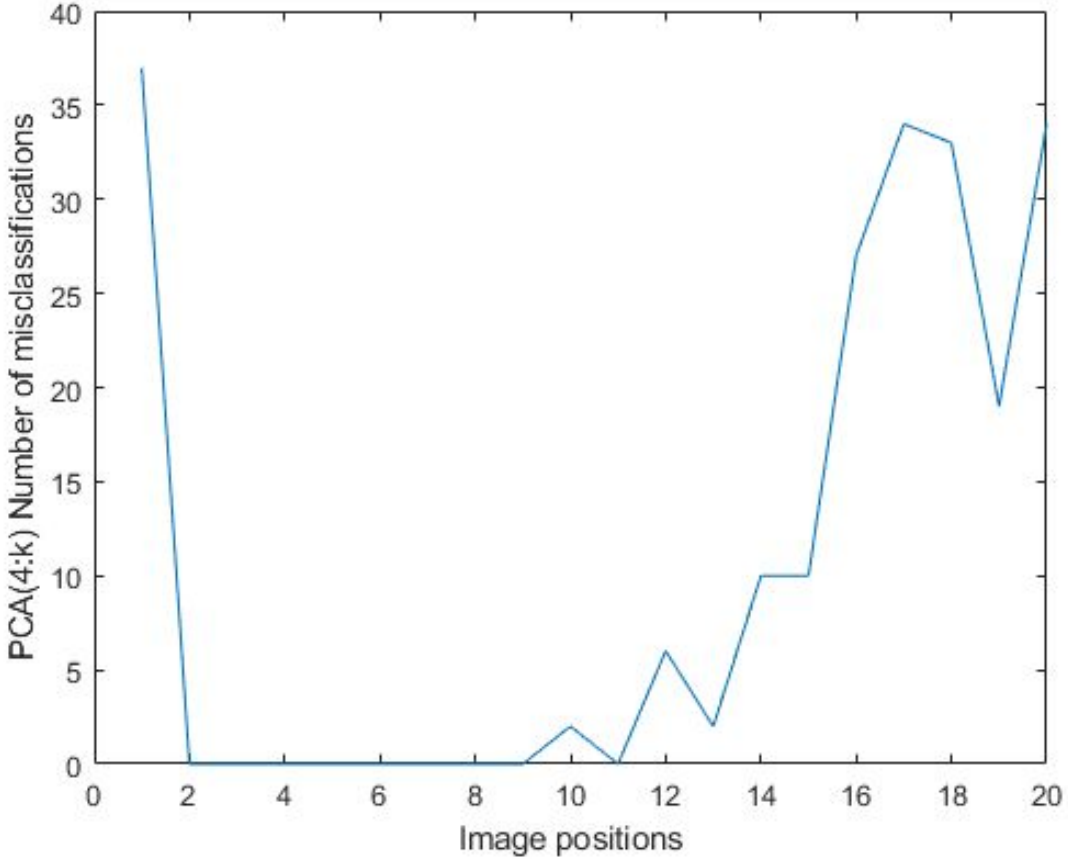
Lighting conditions varied a lot in the Data set

Split up into Test set and Training Set

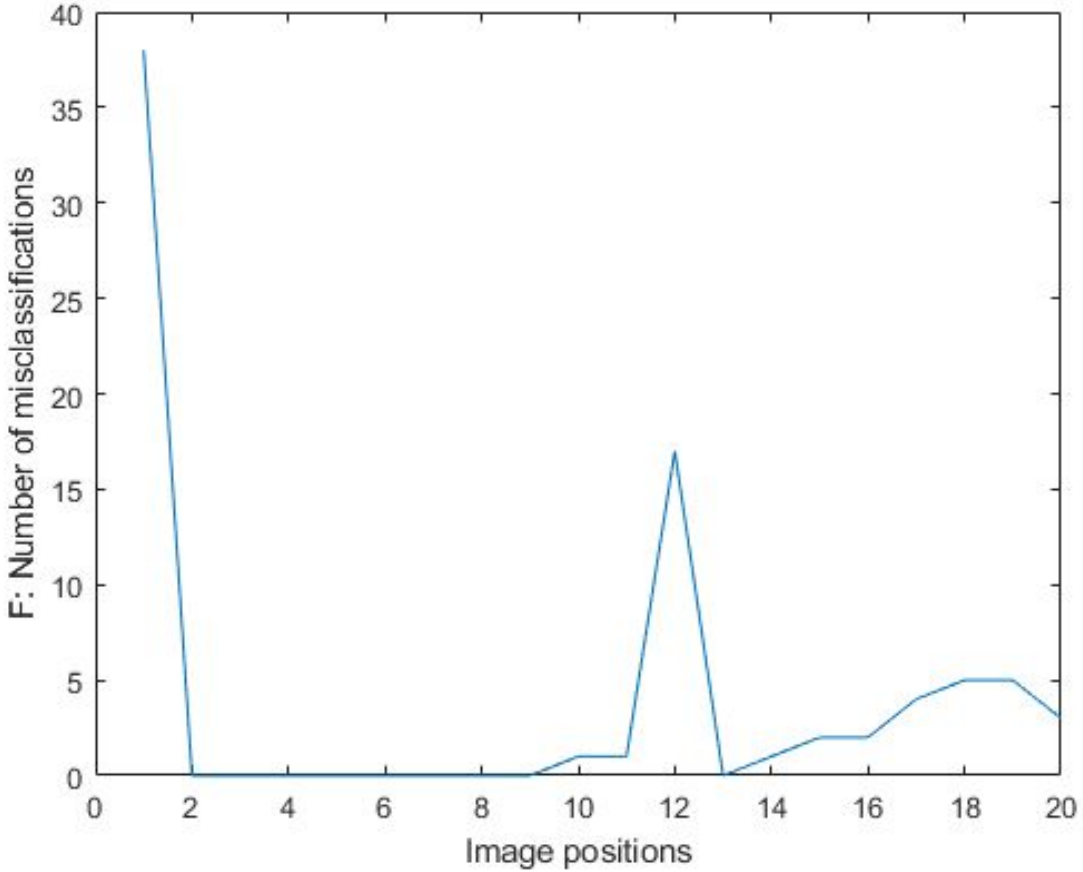
Total 60 images per person and 38 persons

Trained on first 40, Tested on remaining 20

Average light intensity in the Tail of the Test Dataset was lower.



There is a clear pattern to where PCA fails
For lower Intensity test case classification



No clear trend for where FLD fails
Error does not increase as Intensity decreases

Experiment 2

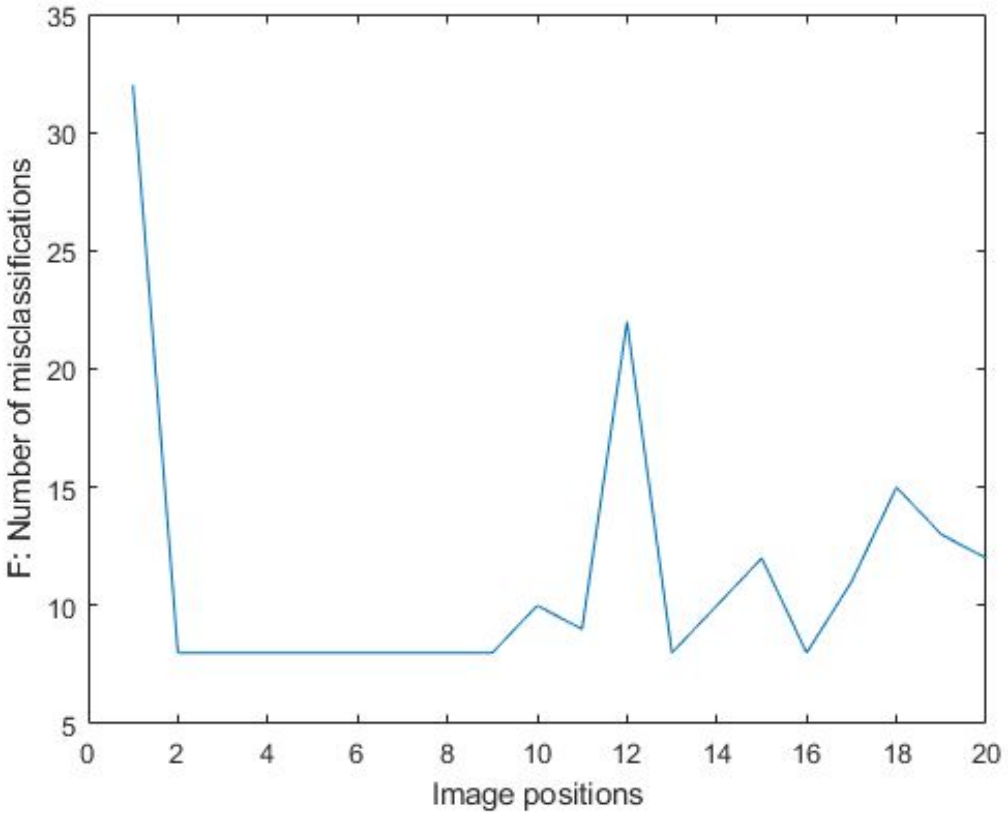
As suggested in the paper we tried training different classes by different variations in Intensity

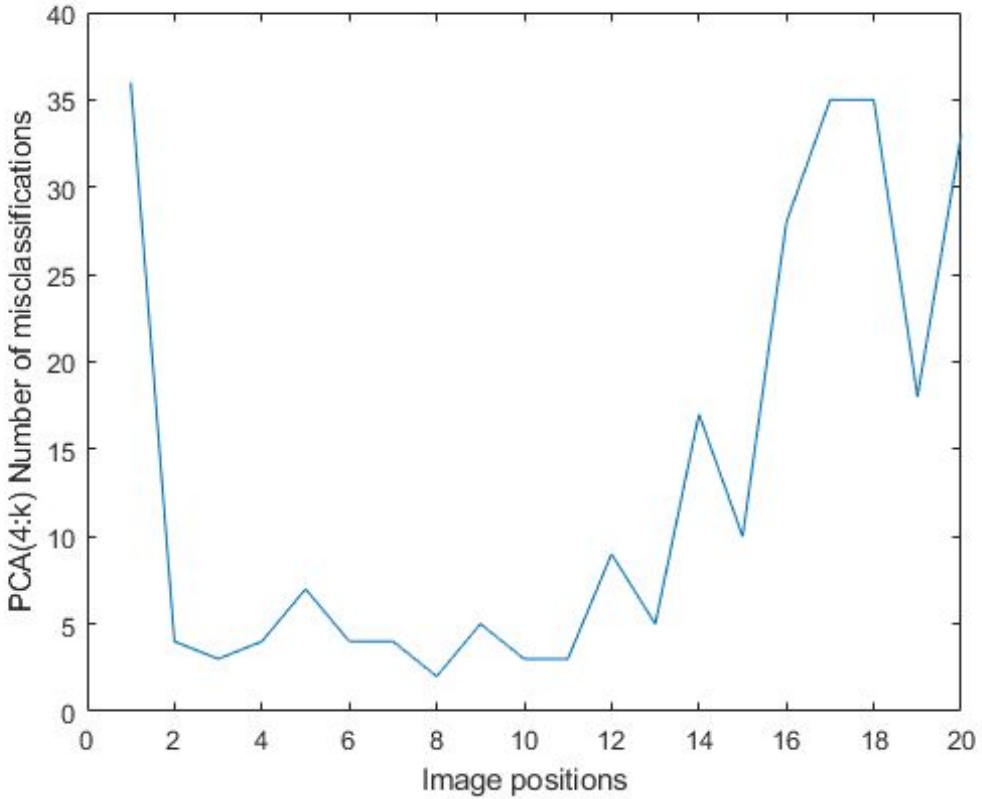
In the following analysis

Person IDs: 1 - 9 were trained with less Intensity varying samples

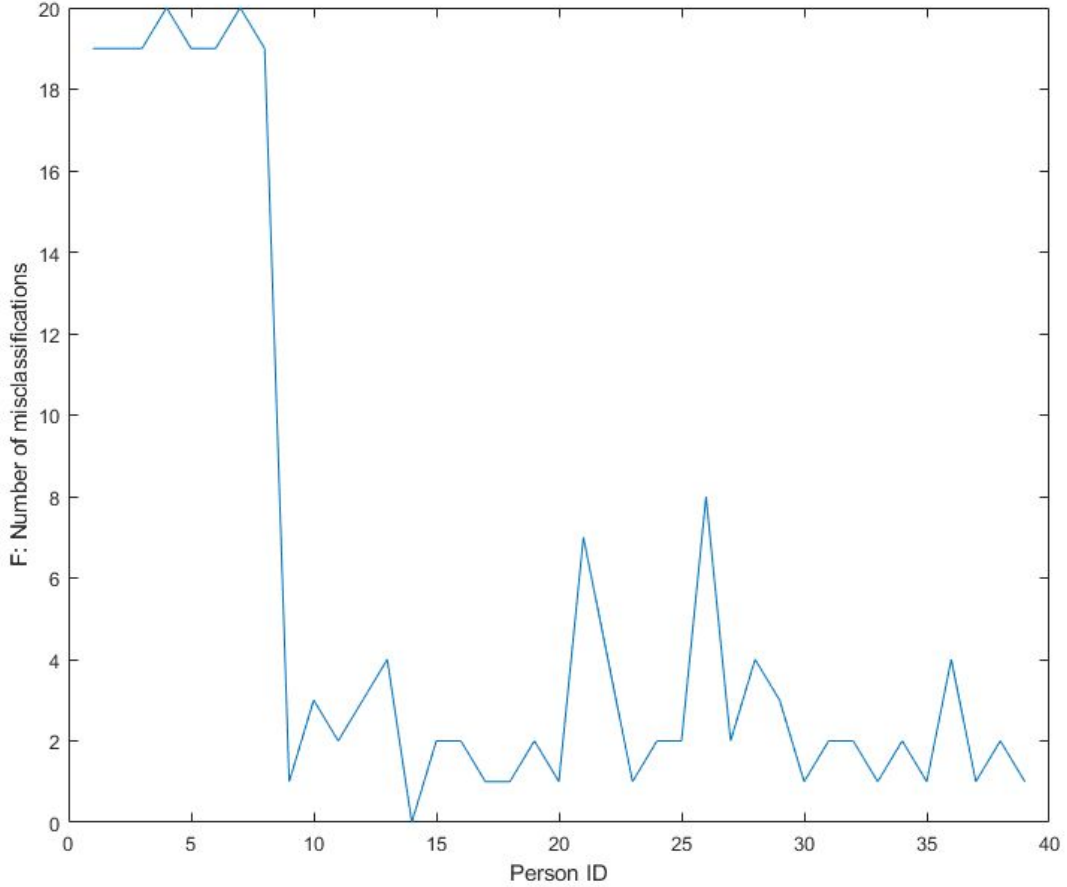
Person IDs: 10 - 39 were trained with more Intensity varying samples

Positions: Trend remains similar as Before



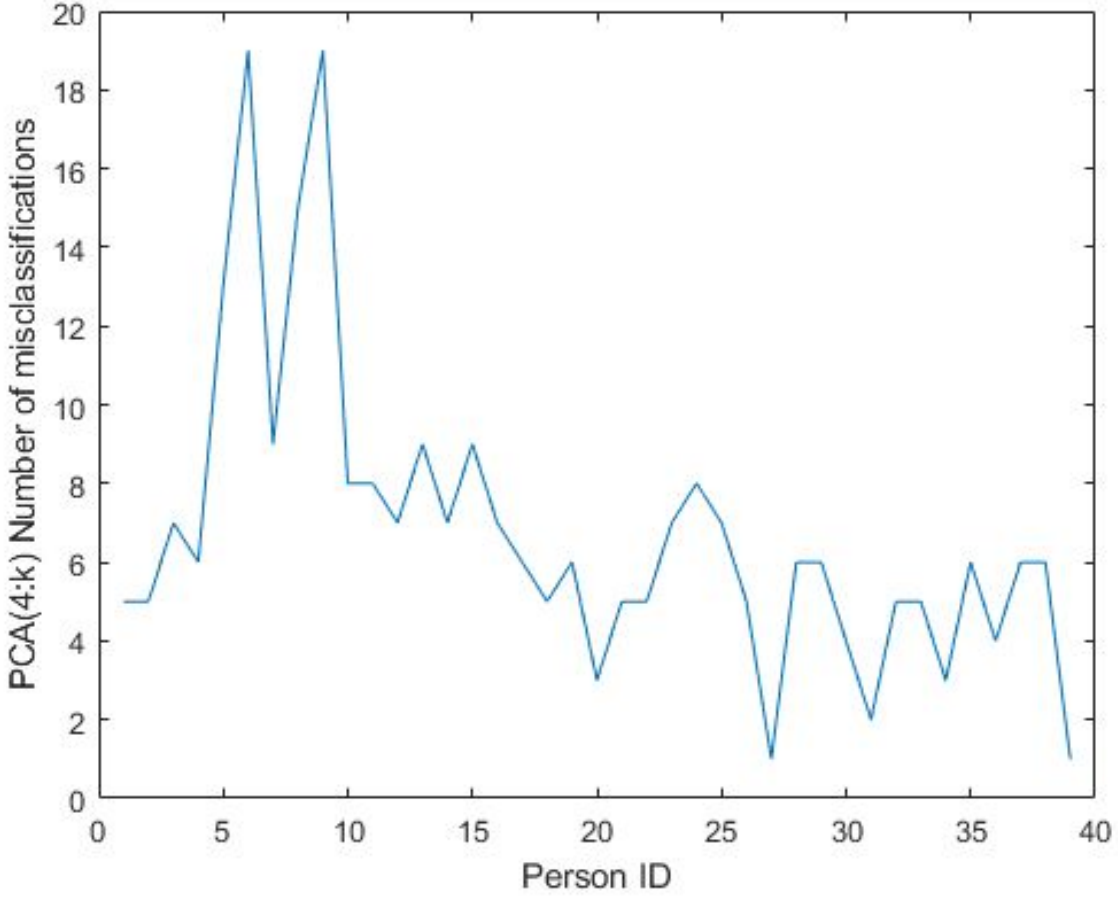


As before PCA fails for low intensity while FLD failure is intensity independent



When we check how the misclassifications were distributed across person IDs (Classes for FLD)

Then the classes 1-9 which had training data with lesser light intensity variation are misclassified most often



The same trend is observed for PCA