Assignment 6 Report

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Project summary:

In this project we had to implement the concept of Eigen Faces to classify different subjects correctly. Here, we first read the training images from the directory which has multiple sub directories, then we compute the mean face of all these images and subtract the mean face from the training matrix. Next, we perform eigen decomposition to obtain the vectors and its corresponding eigen values in the sorted form. The ascending order is important as we next select the top k prominent features of this matrix. Then we compute the eigen faces using the selected top features. We then project it to subspace to obtain the alpha value which represents the training feature vectors. Then we read the testing data and convert it to a matrix and then subtract the mean face from it to retain the pixel specific properties. Then we obtain the testing alpha by multiplying it with the eigen faces obtain before. Finally, we use different similarity metrics to find the most similar images and the most similar subjects.

Algorithmic Approach:

1. Read the training data using and convert it to a matrix where each row corresponds to an image and each column is the pixel in the image.
2. Calculate the mean of the image dataset per row and then subtract it from each row.
3. Perform the Eigen decomposition to obtain the eigen vectors and the corresponding eigen values sorted in the ascending order.
4. Select the top k eigen values (last k values in the matrix).
5. We then multiply the mean subtracted matrix with the selected K feature matrix to obtain the Eigen faces.
6. We then obtain the training alpha by multiplying the eigen faces with the image matrix.
7. Finally after extracting the training feature vectors we now read the testing images and perform the same steps and subtract the mean face from it to retain the pixel centric features.
8. Then we multiply the matrix with the eigen faces to get the testing alpha.
9. Using the testing and training feature vectors we perform the inference and check for the accuracy of the image being classified correctly and the subjects being classified correctly using different similarity metrics and finally obtain the results.

Intermediate Results:

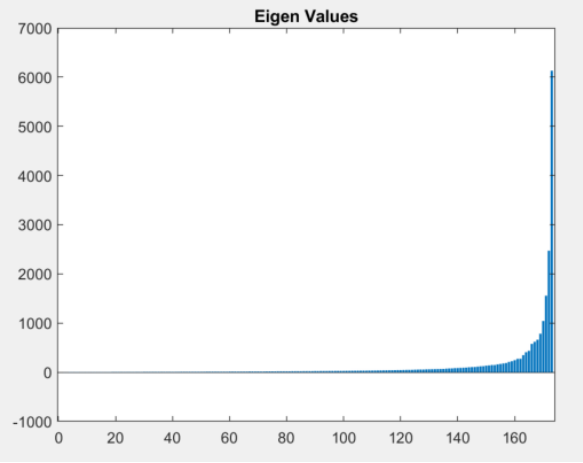

Figure 1: Eigen Values

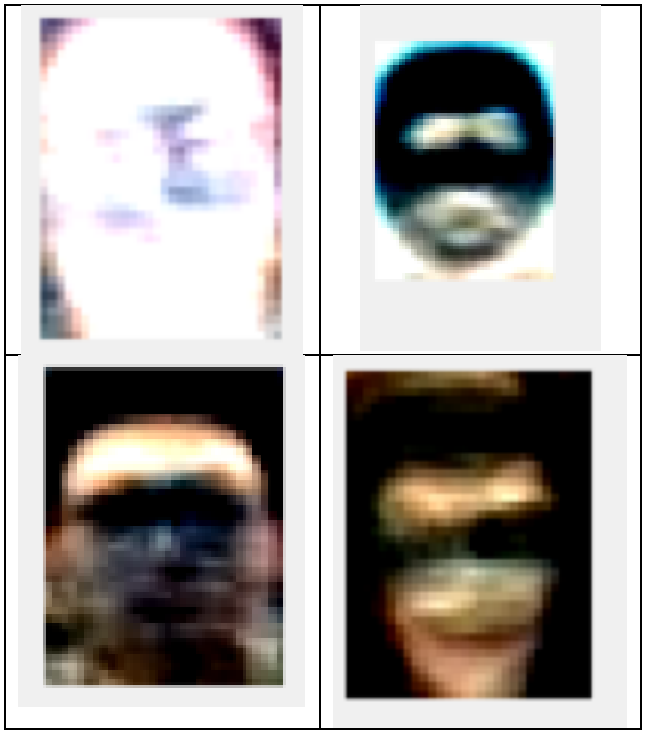

Table 1: Eigen faces after the decomposition and multiplication with image matrix

Final results:

Eigen Faces Project: K = 50

Euclidean

Accuracy of Face Images: 0.43

Accuracy of Subjects: 0.64

Minkowski

Accuracy of Face Images: 0.43

Accuracy of Subjects: 0.64

CityBlock

Accuracy of Face Images: 0.56

Accuracy of Subjects: 0.64

Mahalanobis

Accuracy of Face Images: 0.51

Accuracy of Subjects: 0.64

The project has been tweaked with different color spaces, different similarity metrics and different K values. The results of which have been shown below repectively.

RGB:

	Euclidean			Minkowski			CityBlock			Mahalanobis	
K	Face	Subject	K	Face	Subject	K	Face	Subject	K	Face	Subject
1	0.05914	0.571429	1	0.05914	0.571429	1	0.05914	0.571429	1	0.05913978	0.571429
11	0.403226	0.571429	11	0.403226	0.571429	11	0.44086	0.571429	11	0.57526882	0.571429
21	0.413978	0.535714	21	0.413978	0.535714	21	0.510753	0.535714	21	0.59677419	0.535714
31	0.430108	0.678571	31	0.430108	0.678571	31	0.537634	0.678571	31	0.59677419	0.678571
41	0.424731	0.642857	41	0.424731	0.642857	41	0.526882	0.642857	41	0.61827957	0.642857
51	0.424731	0.75	51	0.424731	0.75	51	0.526882	0.75	51	0.58602151	0.75
61	0.430108	0.571429	61	0.430108	0.571429	61	0.532258	0.571429	61	0.59139785	0.571429
71	0.430108	0.607143	71	0.430108	0.607143	71	0.548387	0.607143	71	0.56451613	0.607143
81	0.430108	0.642857	81	0.430108	0.642857	81	0.548387	0.642857	81	0.55913978	0.642857
91	0.430108	0.642857	91	0.430108	0.642857	91	0.553763	0.642857	91	0.52150538	0.642857
101	0.430108	0.642857	101	0.430108	0.642857	101	0.55914	0.642857	101	0.5	0.642857
111	0.430108	0.571429	111	0.430108	0.571429	111	0.564516	0.571429	111	0.5	0.571429
121	0.430108	0.642857	121	0.430108	0.642857	121	0.55914	0.642857	121	0.48387097	0.642857
131	0.430108	0.607143	131	0.430108	0.607143	131	0.55914	0.607143	131	0.44623656	0.607143
141	0.430108	0.5	141	0.430108	0.5	141	0.55914	0.5	141	0.44623656	0.5
151	0.430108	0.642857	151	0.430108	0.642857	151	0.55914	0.642857	151	0.43010753	0.642857
161	0.430108	0.642857	161	0.430108	0.642857	161	0.55914	0.642857	161	0.47849462	0.642857
171	0.430108	0.607143	171	0.430108	0.607143	171	0.55914	0.607143	171	0.52688172	0.607143

Table 2: Different Accuracies of Face and Subject for different similarity metrics

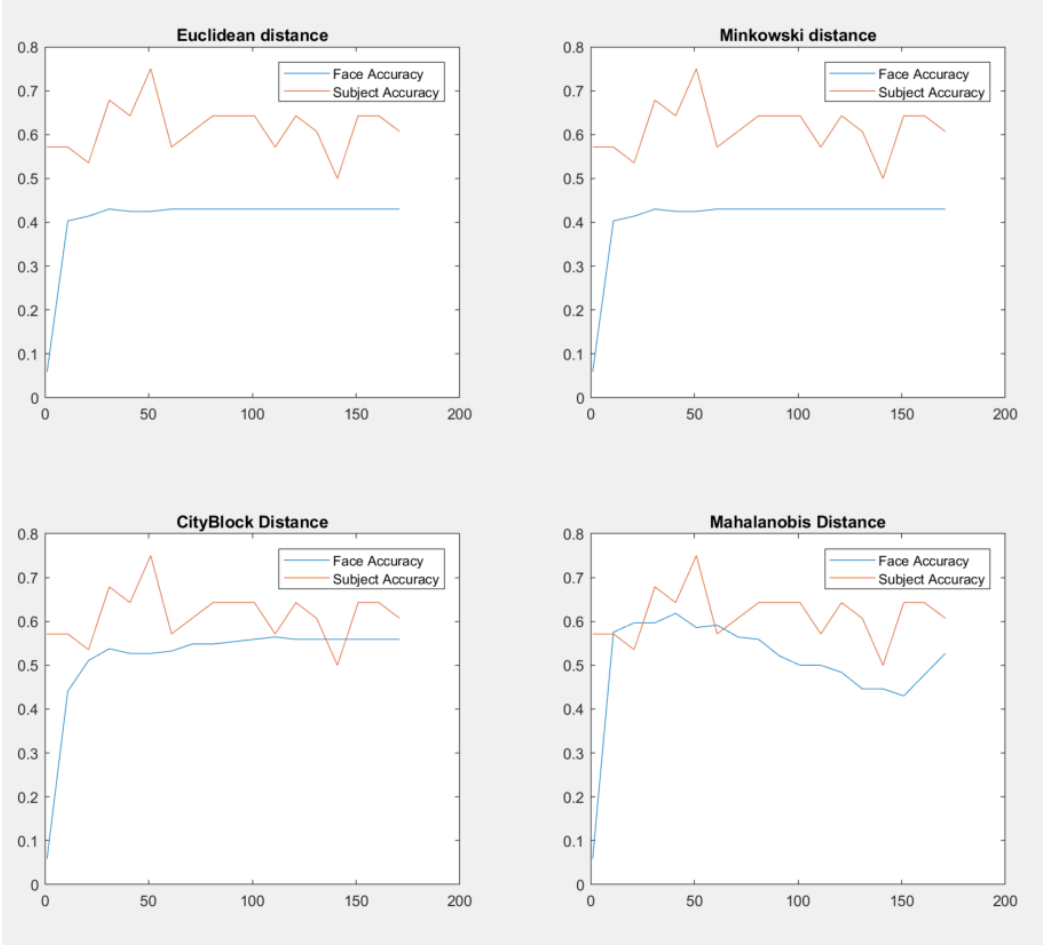

Figure 2: Visualization of the above numerical data

Observation:

The face accuracy increases as the K value increases for all the 4 metrics but after some time every metric accuracy except mahalanobis become nearly constant. The subject accuracy however remains almost constant for all the metrics.

YCbCr:

	Euclidean			Minkowski			CityBlock			Mahalanobis	
K	Face	Subject	K	Face	Subject	K	Face	Subject	K	Face	Subject
1	0.053763	0.642857	1	0.053763	0.642857	1	0.053763	0.642857	1	0.05376344	0.642857
11	0.365591	0.607143	11	0.365591	0.607143	11	0.413978	0.607143	11	0.45698925	0.607143
21	0.387097	0.5	21	0.387097	0.5	21	0.451613	0.5	21	0.55376344	0.5
31	0.403226	0.571429	31	0.403226	0.571429	31	0.473118	0.571429	31	0.6344086	0.571429
41	0.397849	0.535714	41	0.397849	0.535714	41	0.483871	0.535714	41	0.61290323	0.535714
51	0.397849	0.642857	51	0.397849	0.642857	51	0.483871	0.642857	51	0.62903226	0.642857
61	0.397849	0.678571	61	0.397849	0.678571	61	0.5	0.678571	61	0.61290323	0.678571
71	0.397849	0.5	71	0.397849	0.5	71	0.5	0.5	71	0.62903226	0.5
81	0.397849	0.607143	81	0.397849	0.607143	81	0.505376	0.607143	81	0.61290323	0.607143
91	0.397849	0.607143	91	0.397849	0.607143	91	0.5	0.607143	91	0.58602151	0.607143
101	0.397849	0.571429	101	0.397849	0.571429	101	0.505376	0.571429	101	0.52150538	0.571429
111	0.397849	0.571429	111	0.397849	0.571429	111	0.505376	0.571429	111	0.52688172	0.571429
121	0.397849	0.642857	121	0.397849	0.642857	121	0.505376	0.642857	121	0.53763441	0.642857
131	0.397849	0.678571	131	0.397849	0.678571	131	0.505376	0.678571	131	0.46774194	0.678571
141	0.397849	0.571429	141	0.397849	0.571429	141	0.510753	0.571429	141	0.46236559	0.571429
151	0.397849	0.642857	151	0.397849	0.642857	151	0.505376	0.642857	151	0.44623656	0.642857
161	0.397849	0.642857	161	0.397849	0.642857	161	0.505376	0.642857	161	0.43010753	0.642857
171	0.397849	0.678571	171	0.397849	0.678571	171	0.505376	0.678571	171	0.55913978	0.678571

Table 3: Different Accuracies of Face and Subject for different similarity metrics

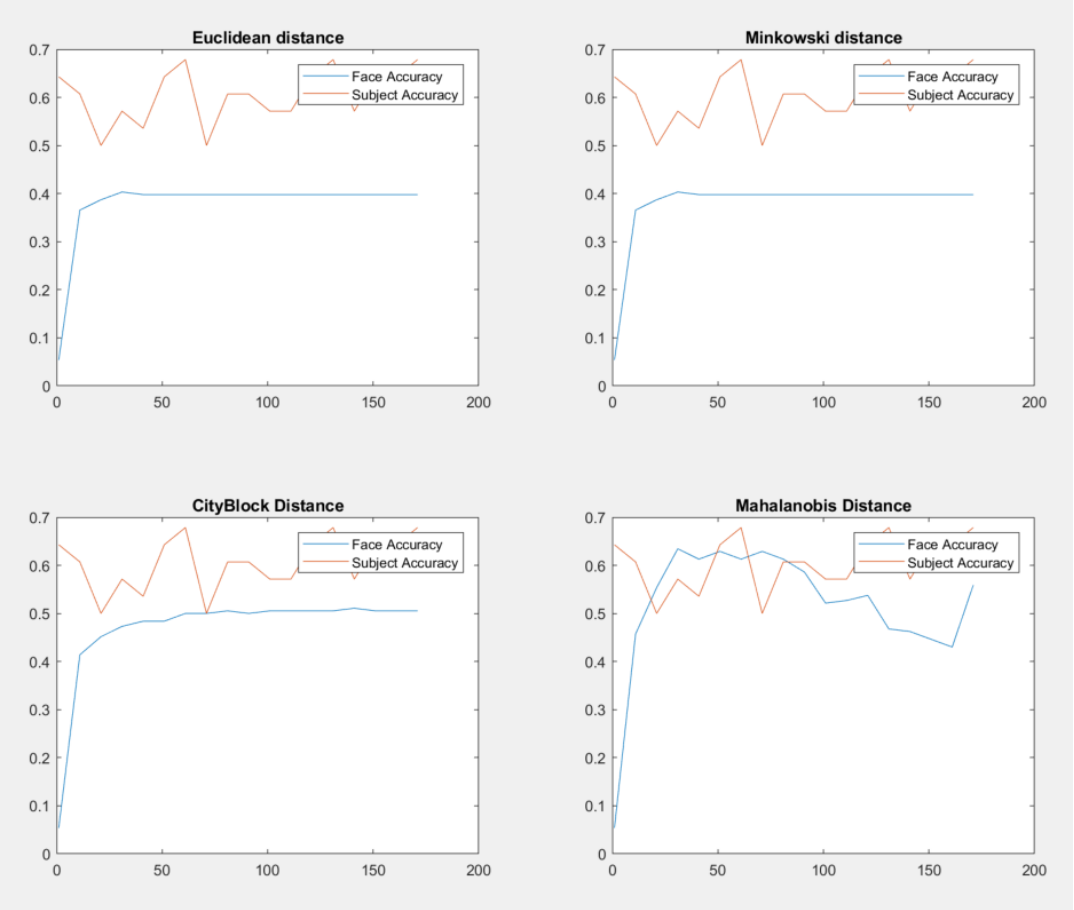

Figure 3: Visualization of the above numerical data

Observation:

The face accuracy increases as the K value increases for all the 4 metrics but after some time every metric accuracy except Mahalanobis become nearly constant. Mahalanobis fluctuates when the K value increases. The subject accuracy however remains almost constant for all the metrics.

HSV:

	Euclidean			Minkowski			CityBlock			Mahalanobis	
K	Face	Subject	K	Face	Subject	K	Face	Subject	K	Face	Subject
1	0.080645	0.607143	1	0.080645	0.607143	1	0.080645	0.607143	1	0.08064516	0.607143
11	0.284946	0.678571	11	0.284946	0.678571	11	0.317204	0.678571	11	0.43010753	0.678571
21	0.349462	0.607143	21	0.349462	0.607143	21	0.354839	0.607143	21	0.47849462	0.607143
31	0.354839	0.607143	31	0.354839	0.607143	31	0.397849	0.607143	31	0.48387097	0.607143
41	0.354839	0.714286	41	0.354839	0.714286	41	0.392473	0.714286	41	0.47849462	0.714286
51	0.354839	0.642857	51	0.354839	0.642857	51	0.408602	0.642857	51	0.47849462	0.642857
61	0.365591	0.678571	61	0.365591	0.678571	61	0.424731	0.678571	61	0.45698925	0.678571
71	0.365591	0.678571	71	0.365591	0.678571	71	0.430108	0.678571	71	0.44086022	0.678571
81	0.365591	0.714286	81	0.365591	0.714286	81	0.446237	0.714286	81	0.41935484	0.714286
91	0.365591	0.607143	91	0.365591	0.607143	91	0.462366	0.607143	91	0.3655914	0.607143
101	0.365591	0.571429	101	0.365591	0.571429	101	0.446237	0.571429	101	0.35483871	0.571429
111	0.365591	0.571429	111	0.365591	0.571429	111	0.446237	0.571429	111	0.34408602	0.571429
121	0.365591	0.571429	121	0.365591	0.571429	121	0.451613	0.571429	121	0.29032258	0.571429
131	0.365591	0.571429	131	0.365591	0.571429	131	0.456989	0.571429	131	0.31182796	0.571429
141	0.365591	0.535714	141	0.365591	0.535714	141	0.456989	0.535714	141	0.27956989	0.535714
151	0.365591	0.571429	151	0.365591	0.571429	151	0.456989	0.571429	151	0.27956989	0.571429
161	0.365591	0.678571	161	0.365591	0.678571	161	0.462366	0.678571	161	0.27419355	0.678571
171	0.365591	0.571429	171	0.365591	0.571429	171	0.451613	0.571429	171	0.44623656	0.571429

Table 4: Different Accuracies of Face and Subject for different similarity metrics

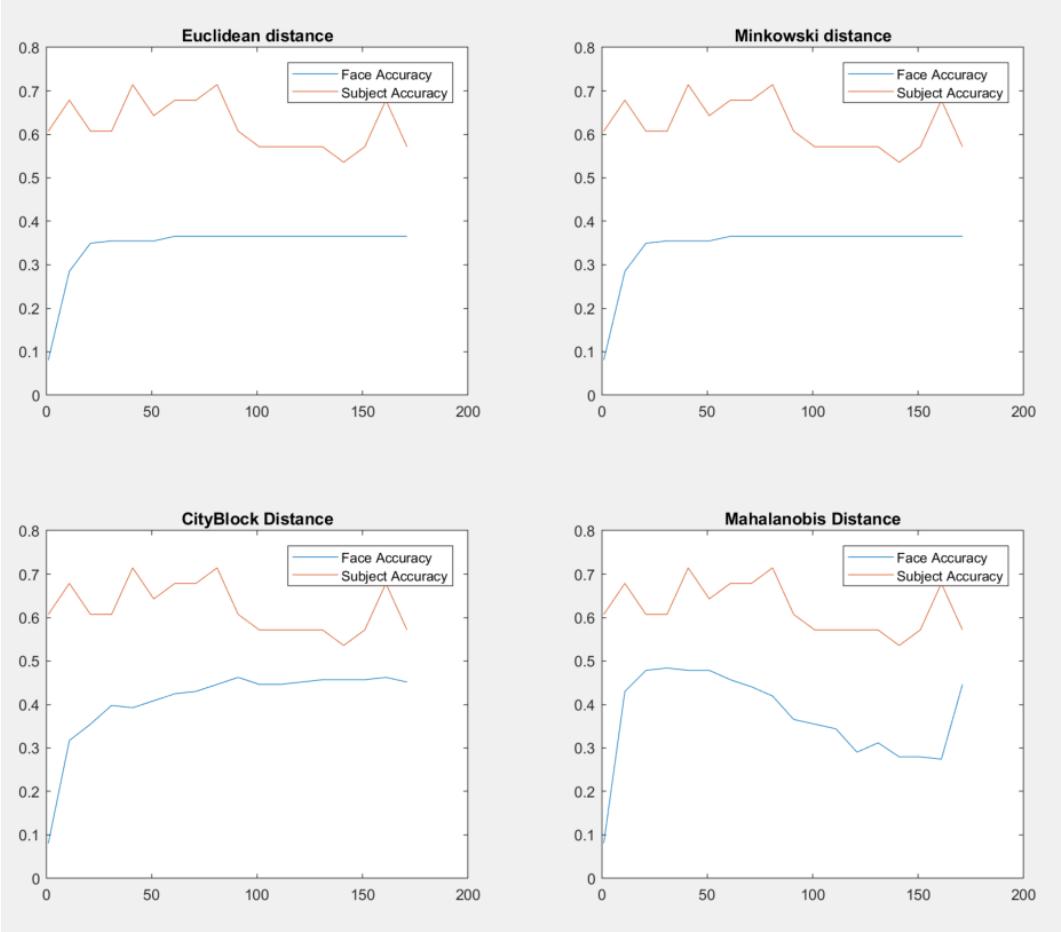

Figure 4: Visualization of the above numerical data

Observation:

The face accuracy increases as the K value increases for all the 4 metrics but after some time every metric accuracy except Mahalanobis become nearly constant and CityBlock. Mahalanobis fluctuates when the K value increases at higher K but later decreases and finally again increases. City block increases gradually as K increases. The subject accuracy however remains almost constant for all the metrics.

HSVYCbCr:

	Euclidean			Minkowski			CityBlock			Mahalanobis	
K	Face	Subject	K	Face	Subject	K	Face	Subject	K	Face	Subject
1	0.053763	0.642857	1	0.053763	0.642857	1	0.053763	0.642857	1	0.05376344	0.642857
11	0.365591	0.571429	11	0.365591	0.571429	11	0.413978	0.571429	11	0.45698925	0.571429
21	0.387097	0.5	21	0.387097	0.5	21	0.451613	0.5	21	0.55376344	0.5
31	0.403226	0.642857	31	0.403226	0.642857	31	0.473118	0.642857	31	0.6344086	0.642857
41	0.397849	0.535714	41	0.397849	0.535714	41	0.483871	0.535714	41	0.61290323	0.535714
51	0.397849	0.607143	51	0.397849	0.607143	51	0.483871	0.607143	51	0.62903226	0.607143
61	0.397849	0.678571	61	0.397849	0.678571	61	0.5	0.678571	61	0.61290323	0.678571
71	0.397849	0.607143	71	0.397849	0.607143	71	0.5	0.607143	71	0.62903226	0.607143
81	0.397849	0.642857	81	0.397849	0.642857	81	0.505376	0.642857	81	0.61290323	0.642857
91	0.397849	0.714286	91	0.397849	0.714286	91	0.5	0.714286	91	0.58602151	0.714286
101	0.397849	0.714286	101	0.397849	0.714286	101	0.505376	0.714286	101	0.52150538	0.714286
111	0.397849	0.642857	111	0.397849	0.642857	111	0.505376	0.642857	111	0.53225806	0.642857
121	0.397849	0.535714	121	0.397849	0.535714	121	0.505376	0.535714	121	0.53763441	0.535714
131	0.397849	0.642857	131	0.397849	0.642857	131	0.505376	0.642857	131	0.46774194	0.642857
141	0.397849	0.607143	141	0.397849	0.607143	141	0.510753	0.607143	141	0.46236559	0.607143
151	0.397849	0.607143	151	0.397849	0.607143	151	0.505376	0.607143	151	0.4516129	0.607143
161	0.397849	0.607143	161	0.397849	0.607143	161	0.505376	0.607143	161	0.43010753	0.607143
171	0.397849	0.714286	171	0.397849	0.714286	171	0.505376	0.714286	171	0.55913978	0.714286

Table 5: Different Accuracies of Face and Subject for different similarity metrics

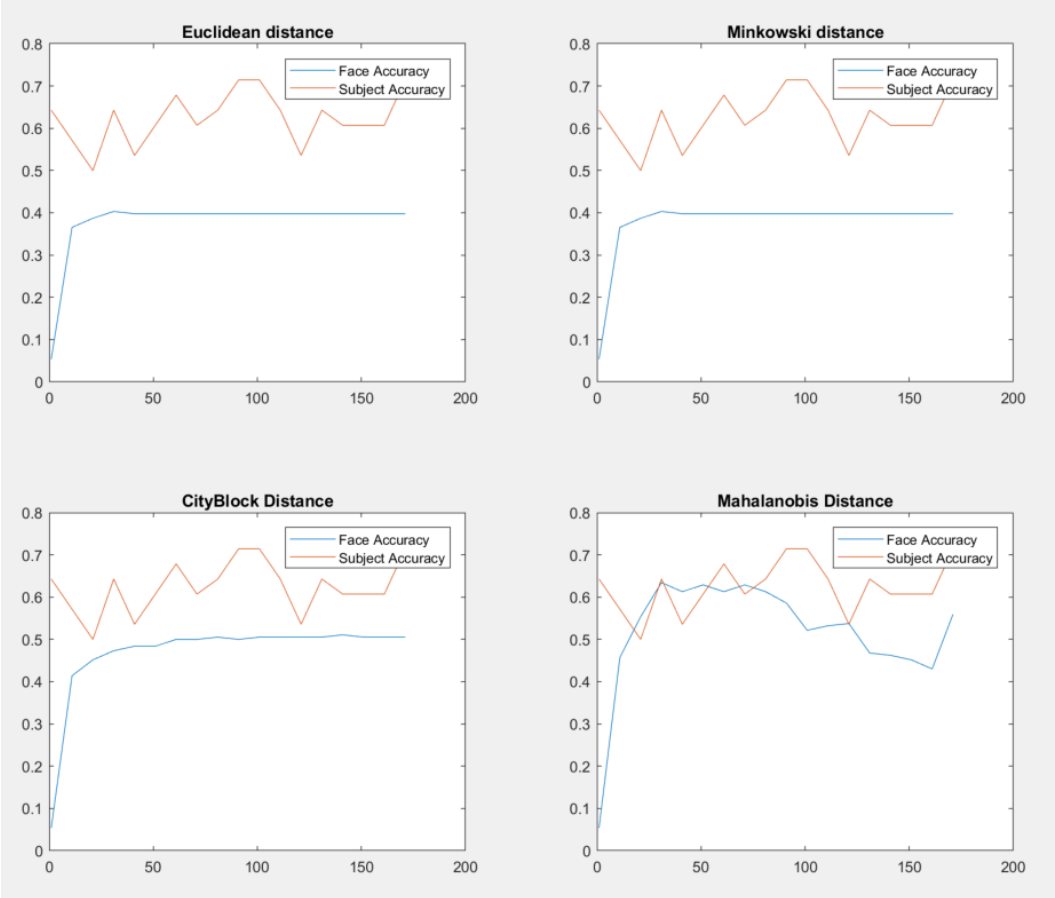

Figure 5: Visualization of the above numerical data

Observation:

The face accuracy increases as the K value increases for all the 4 metrics but after some time every metric accuracy except Mahalanobis become nearly constant and CityBlock. Mahalanobis fluctuates when the K value increases at higher K but later decreases and finally again increases. City block increases gradually as K increases. The subject accuracy however remains almost constant for all the metrics.

Gradient:

	Euclidean			Minkowski			CityBlock			Mahalanobis	
K	Face	Subject	K	Face	Subject	K	Face	Subject	K	Face	Subject
1	0.010753	0.535714	1	0.010753	0.535714	1	0.010753	0.535714	1	0.01075269	0.535714
11	0.360215	0.678571	11	0.360215	0.678571	11	0.413978	0.678571	11	0.47849462	0.678571
21	0.408602	0.535714	21	0.408602	0.535714	21	0.505376	0.535714	21	0.58602151	0.535714
31	0.408602	0.5	31	0.408602	0.5	31	0.55914	0.5	31	0.60752688	0.5
41	0.413978	0.642857	41	0.413978	0.642857	41	0.564516	0.642857	41	0.59677419	0.642857
51	0.419355	0.571429	51	0.419355	0.571429	51	0.564516	0.571429	51	0.6344086	0.571429
61	0.419355	0.678571	61	0.419355	0.678571	61	0.575269	0.678571	61	0.65053763	0.678571
71	0.419355	0.535714	71	0.419355	0.535714	71	0.575269	0.535714	71	0.60215054	0.535714
81	0.419355	0.571429	81	0.419355	0.571429	81	0.575269	0.571429	81	0.61827957	0.571429
91	0.419355	0.571429	91	0.419355	0.571429	91	0.575269	0.571429	91	0.60752688	0.571429
101	0.419355	0.642857	101	0.419355	0.642857	101	0.575269	0.642857	101	0.62903226	0.642857
111	0.419355	0.714286	111	0.419355	0.714286	111	0.575269	0.714286	111	0.58064516	0.714286
121	0.419355	0.607143	121	0.419355	0.607143	121	0.575269	0.607143	121	0.54301075	0.607143
131	0.419355	0.535714	131	0.419355	0.535714	131	0.575269	0.535714	131	0.53225806	0.535714
141	0.419355	0.607143	141	0.419355	0.607143	141	0.575269	0.607143	141	0.5	0.607143
151	0.419355	0.571429	151	0.419355	0.571429	151	0.575269	0.571429	151	0.49462366	0.571429
161	0.419355	0.535714	161	0.419355	0.535714	161	0.575269	0.535714	161	0.47311828	0.535714
171	0.419355	0.464286	171	0.419355	0.464286	171	0.575269	0.464286	171	0.46774194	0.464286

Table 6: Different Accuracies of Face and Subject for different similarity metrics

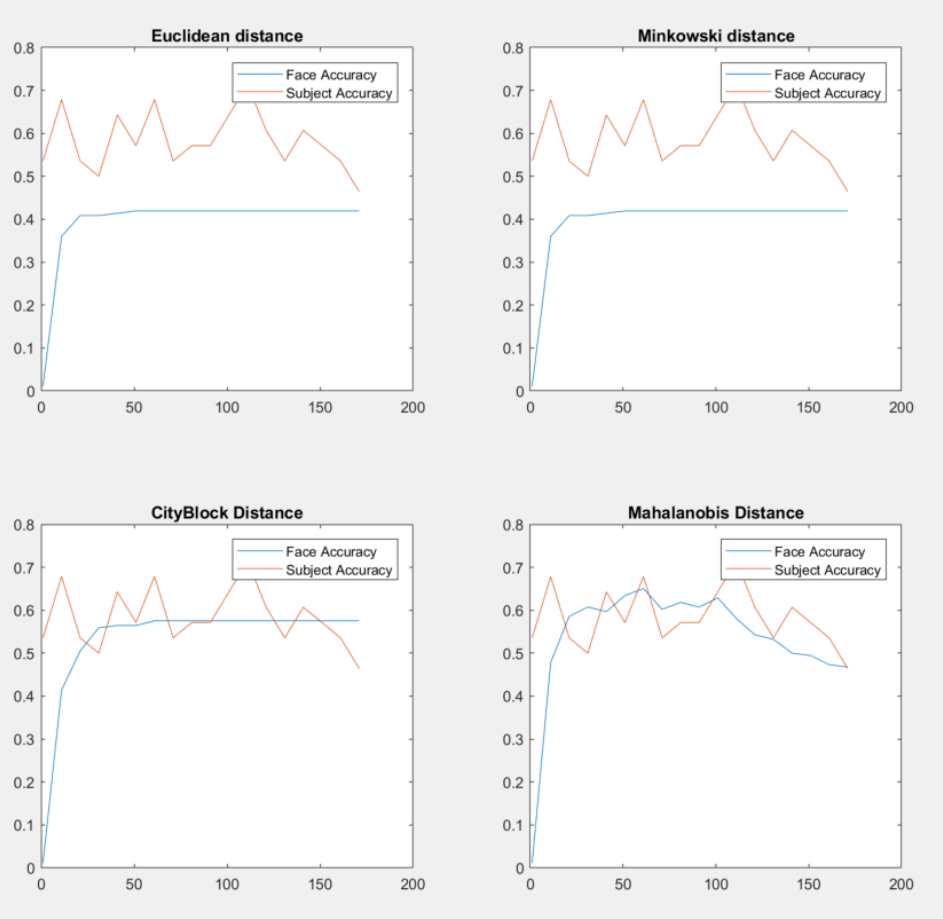

Figure 6: Visualization of the above numerical data

Observation:

The face accuracy increases as the K value increases for all the 4 metrics but after some time every metric accuracy except Mahalanobis become nearly constant. Mahalanobis fluctuates when the K value increases and then decreases. The subject accuracy however remains almost constant for all the metrics.

Gray:

	Euclidean			Minkowski			CityBlock			Mahalanobis	
K	Face	Subject	K	Face	Subject	K	Face	Subject	K	Face	Subject
1	0.102151	0.678571	1	0.102151	0.678571	1	0.102151	0.678571	1	0.10215054	0.678571
11	0.370968	0.464286	11	0.370968	0.464286	11	0.435484	0.464286	11	0.53763441	0.464286
21	0.403226	0.642857	21	0.403226	0.642857	21	0.5	0.642857	21	0.60215054	0.642857
31	0.403226	0.642857	31	0.403226	0.642857	31	0.516129	0.642857	31	0.62903226	0.642857
41	0.408602	0.571429	41	0.408602	0.571429	41	0.543011	0.571429	41	0.61290323	0.571429
51	0.408602	0.607143	51	0.408602	0.607143	51	0.537634	0.607143	51	0.59677419	0.607143
61	0.408602	0.464286	61	0.408602	0.464286	61	0.548387	0.464286	61	0.58602151	0.464286
71	0.408602	0.642857	71	0.408602	0.642857	71	0.548387	0.642857	71	0.54301075	0.642857
81	0.408602	0.642857	81	0.408602	0.642857	81	0.553763	0.642857	81	0.51612903	0.642857
91	0.408602	0.607143	91	0.408602	0.607143	91	0.55914	0.607143	91	0.48387097	0.607143
101	0.408602	0.607143	101	0.408602	0.607143	101	0.564516	0.607143	101	0.45698925	0.607143
111	0.408602	0.535714	111	0.408602	0.535714	111	0.564516	0.535714	111	0.43548387	0.535714
121	0.408602	0.642857	121	0.408602	0.642857	121	0.564516	0.642857	121	0.43010753	0.642857
131	0.408602	0.678571	131	0.408602	0.678571	131	0.55914	0.678571	131	0.40860215	0.678571
141	0.408602	0.642857	141	0.408602	0.642857	141	0.55914	0.642857	141	0.38709677	0.642857
151	0.408602	0.571429	151	0.408602	0.571429	151	0.55914	0.571429	151	0.37096774	0.571429
161	0.408602	0.607143	161	0.408602	0.607143	161	0.564516	0.607143	161	0.37096774	0.607143
171	0.408602	0.678571	171	0.408602	0.678571	171	0.564516	0.678571	171	0.45698925	0.678571

Table 6: Different Accuracies of Face and Subject for different similarity metrics

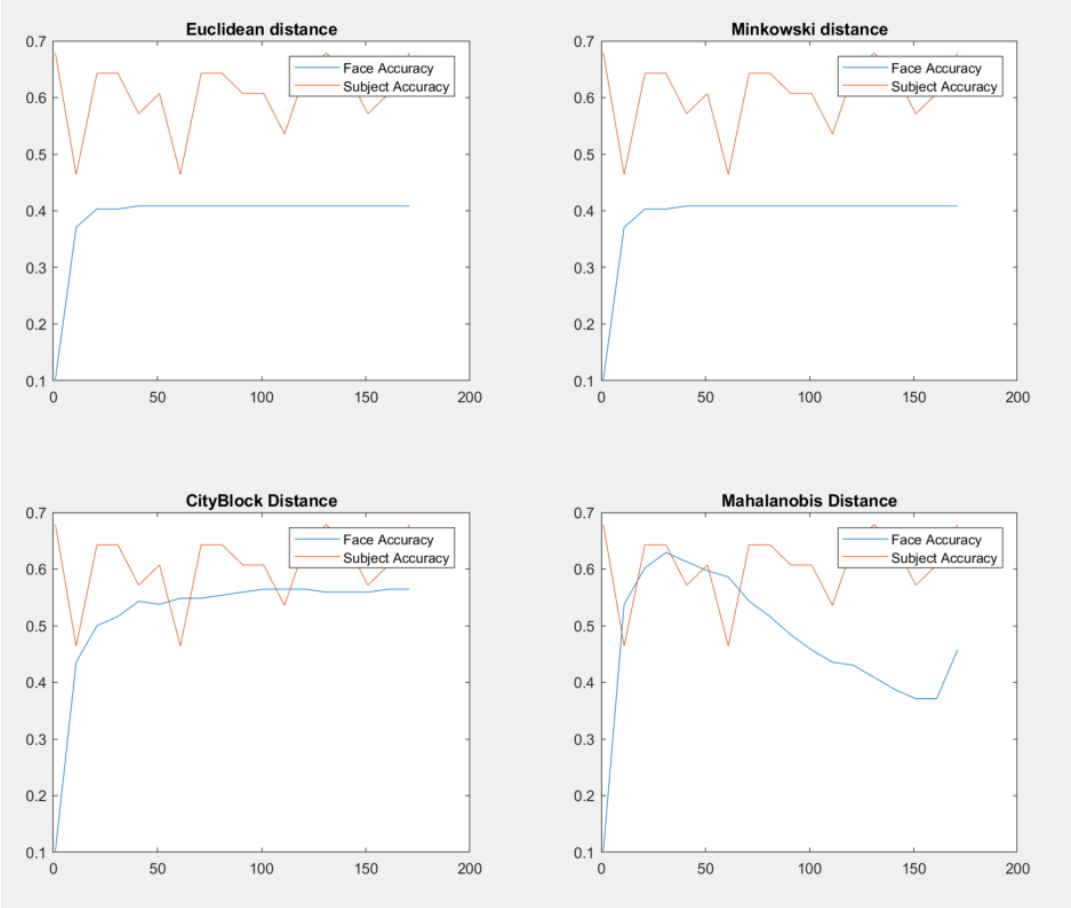

Figure 6: Visualization of the above numerical data

Observation:

The face accuracy increases as the K value increases for all the 4 metrics but after some time every metric accuracy except Mahalanobis become nearly constant. Mahalanobis fluctuates when the K value increases and then decreases and finally increases. The CityBlock distance however increases gradually as the K increases. The subject accuracy however remains almost constant for all the metrics.