ASSIGNMENT 4: FACE DETECTION

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(1) Summary

The aim of this project is to classify images based on the concept of Eigenface approach. We have a training data set, where we need to apply this concept of Eigen vectors in order to identify eigen faces from the training set. We need to follow this procedure for different values of the number of eigen faces chosen for comparison, the maximum of which is the total number of testing images. Using this eigenface approach for classifying faces, we have to find out the total number of images correctly recognized from the entire pool of the testing images and also in case of the subjects of the testing dataset.
A few other things mentioned for us to try out were to compare the faces from the two different sets using different metrics in order to compare the performance. And we also have to try to perform this procedure in different colour spaces.

(2) Brief Outline of Algorithmic Approach

- ➔ The first step is to create a vector of all the images from the training dataset in the required colour space. And then we calculate the mean of all the images.
- ➔ The calculated mean is then subtracted from all the values in the vector and then assign them to a image matrix.
- ➔ Now, we need to find the Eigen Decomposition of the image matrix to obtain eigen vectors and their values.
- ➔ The largest K values perform the better characterization of features. Hence, we can choose the later K values for accuracy from the ascending order of the values from the eigen vectors.
- ➔ From here, we can multiply the top K eigen vectors with image matrix to get the Eigen faces. We finally obtain the training alpha by multiplying the transpose of eigen faces with the image matrix.
- ➔ Now we have to perform the testing, where the testing images are the reference features that are compared with the calculated eigen features using a distance metric.
- ➔ The lesser the distance between the eigen value and the reference image, the more chances of them being recognized correctly. The one with the smallest distance is the match and we calculate its accuracy.
- ➔ We also calculate the subject accuracy where we compare each subject(and their images) in testing with all subjects in training and check which subject in the training has the least distance with the testing. This process is repeated for all the subjects in the testing set.

(3) Intermediate and Final Results

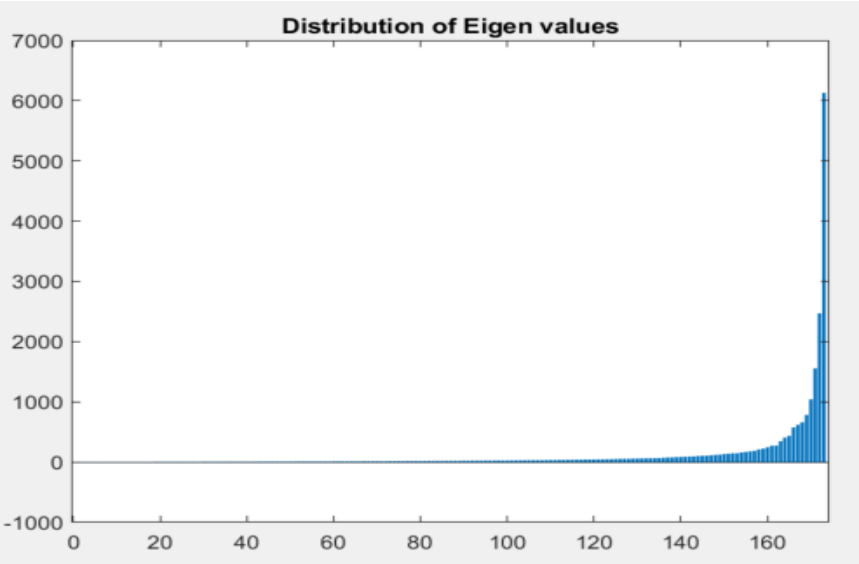

Figure: Eigen Values in Ascending order

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Eigen Faces Algorithm
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Value of K: 100
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Euclidean Image Accuracy: 0.41
Euclidean Subject Accuracy: 0.54
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Manhattan Image Accuracy: 0.56
Manhattan Subject Accuracy: 0.54
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Mahalanobis Image Accuracy: 0.39
Mahalanobis Subject Accuracy: 0.54
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Figure: Final Result

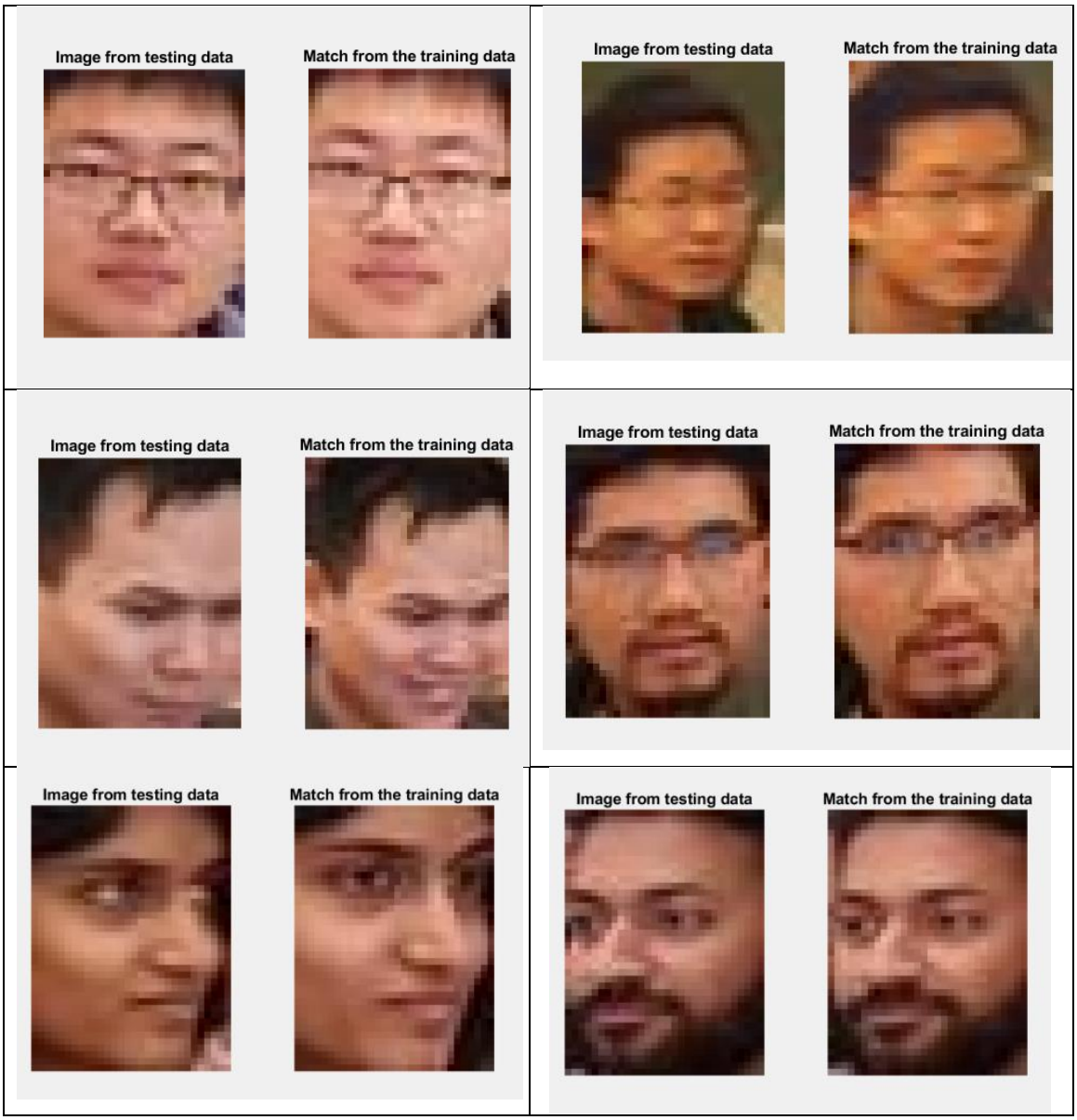

Figure: Output of matched faces

RGB

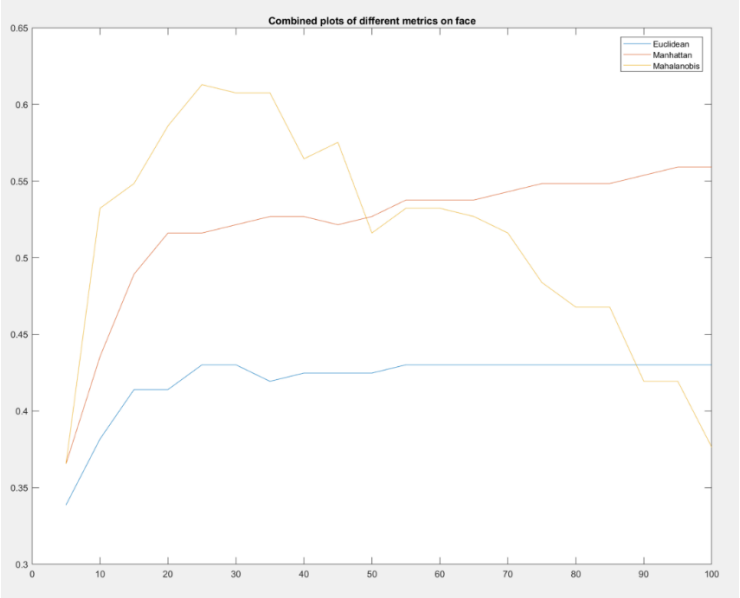

Figure: Accuracy of Faces using different metrics

K	Face Accuracy Euclidean	Face Accuracy Manhattan	Face Accuracy Mahalanobis	Subject Accuracy Euclidean	Subject Accuracy Manhattan	Subject Accuracy Mahalanobis
5	0.33870968	0.365591398	0.365591398	0.571428571	0.571428571	0.571428571
10	0.38172043	0.435483871	0.532258065	0.535714286	0.535714286	0.535714286
15	0.41397849	0.489247312	0.548387097	0.571428571	0.571428571	0.571428571
20	0.41397849	0.516129032	0.586021505	0.535714286	0.535714286	0.535714286
25	0.43010753	0.516129032	0.612903226	0.678571429	0.678571429	0.678571429
30	0.43010753	0.521505376	0.607526882	0.571428571	0.571428571	0.571428571
35	0.41935484	0.52688172	0.607526882	0.642857143	0.642857143	0.642857143
40	0.42473118	0.52688172	0.564516129	0.535714286	0.535714286	0.535714286
45	0.42473118	0.521505376	0.575268817	0.535714286	0.535714286	0.535714286
50	0.42473118	0.52688172	0.516129032	0.571428571	0.571428571	0.571428571
55	0.43010753	0.537634409	0.532258065	0.678571429	0.678571429	0.678571429
60	0.43010753	0.537634409	0.532258065	0.607142857	0.607142857	0.607142857
65	0.43010753	0.537634409	0.52688172	0.607142857	0.607142857	0.607142857
70	0.43010753	0.543010753	0.516129032	0.642857143	0.642857143	0.642857143
75	0.43010753	0.548387097	0.483870968	0.607142857	0.607142857	0.607142857
80	0.43010753	0.548387097	0.467741935	0.571428571	0.571428571	0.571428571
85	0.43010753	0.548387097	0.467741935	0.642857143	0.642857143	0.642857143
90	0.43010753	0.553763441	0.419354839	0.571428571	0.571428571	0.571428571
95	0.43010753	0.559139785	0.419354839	0.678571429	0.678571429	0.678571429
100	0.43010753	0.559139785	0.376344086	0.642857143	0.642857143	0.642857143

HSV

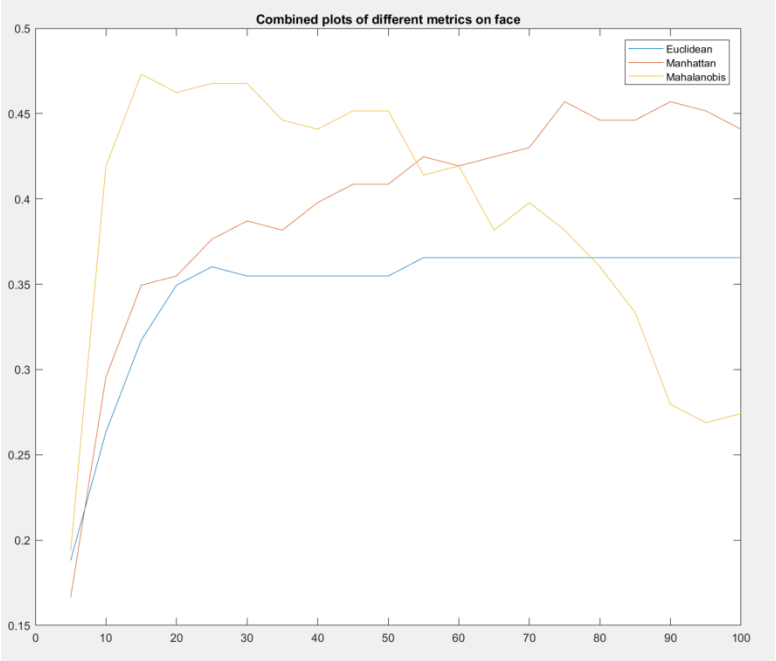

Figure: Accuracy of Faces using different metrics

	Face Accuracy			Subject Accuracy		
K	**Euclidean**	**Manhattan**	**Mahalanobis**	**Euclidean**	**Manhattan**	**Mahalanobis**
5	0.188172	0.166666667	0.19354839	0.571429	0.57142857	0.571428571
10	0.263441	0.295698925	0.41935484	0.607143	0.60714286	0.607142857
15	0.317204	0.349462366	0.47311828	0.607143	0.60714286	0.607142857
20	0.349462	0.35483871	0.46236559	0.571429	0.57142857	0.571428571
25	0.360215	0.376344086	0.46774194	0.75	0.75	0.75
30	0.354839	0.387096774	0.46774194	0.642857	0.64285714	0.642857143
35	0.354839	0.38172043	0.44623656	0.607143	0.60714286	0.607142857
40	0.354839	0.397849462	0.44086022	0.642857	0.64285714	0.642857143
45	0.354839	0.408602151	0.4516129	0.607143	0.60714286	0.607142857
50	0.354839	0.408602151	0.4516129	0.5	0.5	0.5
55	0.365591	0.424731183	0.41397849	0.535714	0.53571429	0.535714286
60	0.365591	0.419354839	0.41935484	0.642857	0.64285714	0.642857143
65	0.365591	0.424731183	0.38172043	0.571429	0.57142857	0.571428571
70	0.365591	0.430107527	0.39784946	0.571429	0.57142857	0.571428571
75	0.365591	0.456989247	0.38172043	0.535714	0.53571429	0.535714286
80	0.365591	0.446236559	0.36021505	0.535714	0.53571429	0.535714286
85	0.365591	0.446236559	0.33333333	0.642857	0.64285714	0.642857143
90	0.365591	0.456989247	0.27956989	0.464286	0.46428571	0.464285714
95	0.365591	0.451612903	0.2688172	0.535714	0.53571429	0.535714286
100	0.365591	0.440860215	0.27419355	0.678571	0.67857143	0.678571429

YCbCr

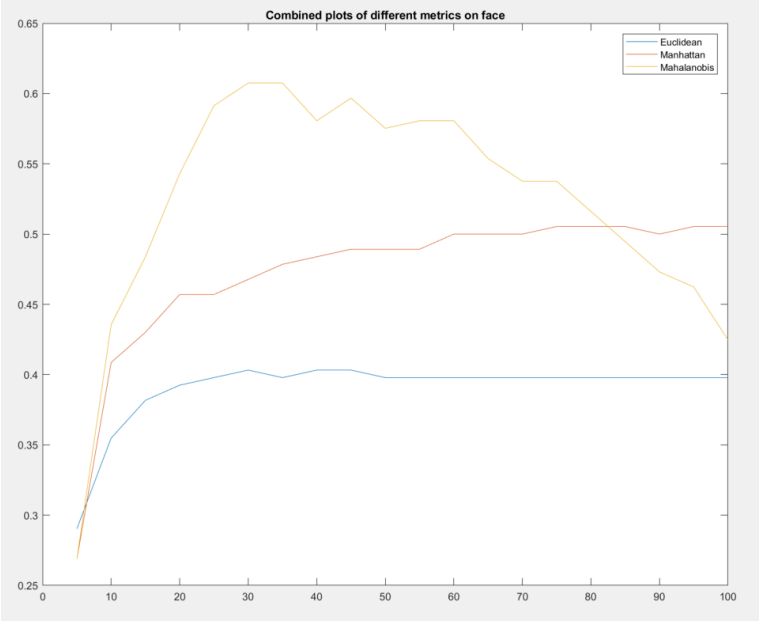

Figure: Accuracy of Faces using different metrics

	Face Accuracy			Subject Accuracy		
K	**Euclidean**	**Manhattan**	**Mahalanobis**	**Euclidean**	**Manhattan**	**Mahalanobis**
5	0.290322581	0.268817204	0.268817204	0.57142857	0.57142857	0.571428571
10	0.35483871	0.408602151	0.435483871	0.64285714	0.64285714	0.642857143
15	0.38172043	0.430107527	0.483870968	0.60714286	0.60714286	0.607142857
20	0.392473118	0.456989247	0.543010753	0.67857143	0.67857143	0.678571429
25	0.397849462	0.456989247	0.591397849	0.64285714	0.64285714	0.642857143
30	0.403225806	0.467741935	0.607526882	0.60714286	0.60714286	0.607142857
35	0.397849462	0.478494624	0.607526882	0.67857143	0.67857143	0.678571429
40	0.403225806	0.483870968	0.580645161	0.64285714	0.64285714	0.642857143
45	0.403225806	0.489247312	0.596774194	0.57142857	0.57142857	0.571428571
50	0.397849462	0.489247312	0.575268817	0.57142857	0.57142857	0.571428571
55	0.397849462	0.489247312	0.580645161	0.64285714	0.64285714	0.642857143
60	0.397849462	0.5	0.580645161	0.64285714	0.64285714	0.642857143
65	0.397849462	0.5	0.553763441	0.60714286	0.60714286	0.607142857
70	0.397849462	0.5	0.537634409	0.5	0.5	0.5
75	0.397849462	0.505376344	0.537634409	0.64285714	0.64285714	0.642857143
80	0.397849462	0.505376344	0.516129032	0.57142857	0.57142857	0.571428571
85	0.397849462	0.505376344	0.494623656	0.67857143	0.67857143	0.678571429
90	0.397849462	0.5	0.47311828	0.67857143	0.67857143	0.678571429
95	0.397849462	0.505376344	0.462365591	0.53571429	0.53571429	0.535714286
100	0.397849462	0.505376344	0.424731183	0.57142857	0.57142857	0.571428571

HSVYCbCr

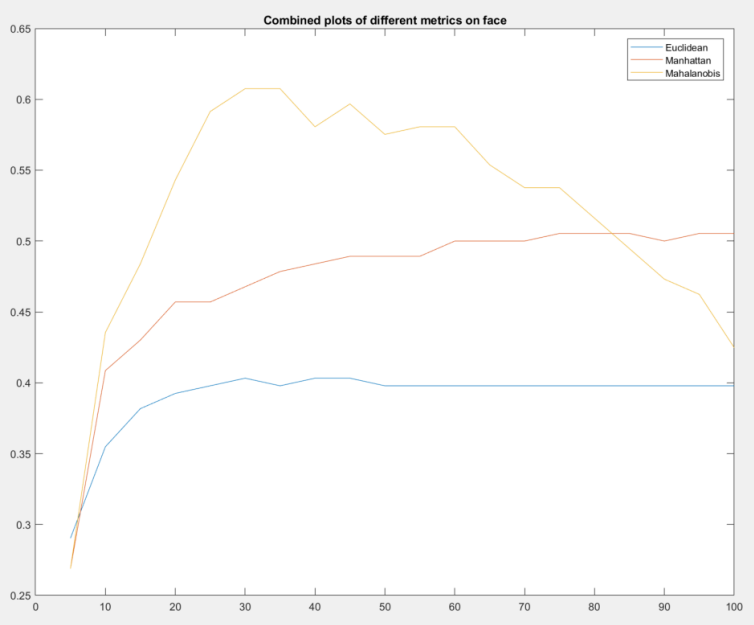

Figure: Accuracy of Faces using different metrics

	Face Accuracy			Subject Accuracy		
K	**Euclidean**	**Manhattan**	**Mahalanobis**	**Euclidean**	**Manhattan**	**Mahalanobis**
5	0.290323	0.268817	0.284946	0.571429	0.571428571	0.571428571
10	0.344086	0.408602	0.451613	0.714286	0.714285714	0.714285714
15	0.397849	0.473118	0.532258	0.535714	0.535714286	0.535714286
20	0.408602	0.510753	0.569892	0.535714	0.535714286	0.535714286
25	0.413978	0.548387	0.543011	0.5	0.5	0.5
30	0.408602	0.537634	0.569892	0.607143	0.607142857	0.607142857
35	0.413978	0.55914	0.596774	0.535714	0.535714286	0.535714286
40	0.413978	0.564516	0.580645	0.678571	0.678571429	0.678571429
45	0.413978	0.564516	0.596774	0.571429	0.571428571	0.571428571
50	0.419355	0.564516	0.602151	0.5	0.5	0.5
55	0.419355	0.575269	0.586022	0.571429	0.571428571	0.571428571
60	0.419355	0.575269	0.586022	0.571429	0.571428571	0.571428571
65	0.419355	0.575269	0.569892	0.642857	0.642857143	0.642857143
70	0.419355	0.575269	0.526882	0.571429	0.571428571	0.571428571
75	0.419355	0.575269	0.537634	0.571429	0.571428571	0.571428571
80	0.419355	0.575269	0.564516	0.535714	0.535714286	0.535714286
85	0.419355	0.575269	0.537634	0.607143	0.607142857	0.607142857
90	0.419355	0.575269	0.521505	0.571429	0.571428571	0.571428571
95	0.419355	0.575269	0.505376	0.75	0.75	0.75
100	0.419355	0.575269	0.473118	0.714286	0.714285714	0.714285714

Gradient

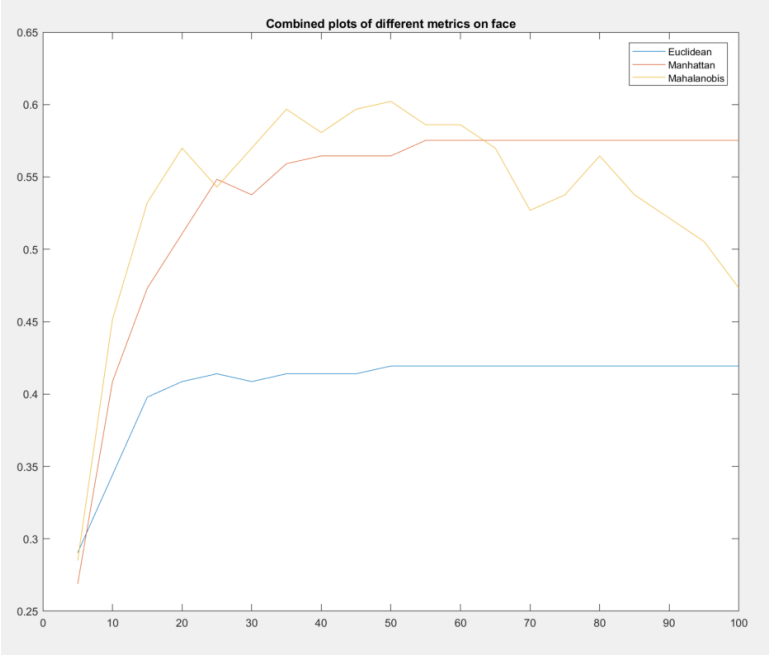

Figure: Accuracy of Faces using different metrics

K	Face Accuracy Euclidean	Manhattan	Mahalanobis	Subject Accuracy Euclidean	Manhattan	Mahalanobis
5	0.290323	0.268817	0.284946	0.571429	0.571429	0.571429
10	0.344086	0.408602	0.451613	0.714286	0.714286	0.714286
15	0.397849	0.473118	0.532258	0.535714	0.535714	0.535714
20	0.408602	0.510753	0.569892	0.535714	0.535714	0.535714
25	0.413978	0.548387	0.543011	0.5	0.5	0.5
30	0.408602	0.537634	0.569892	0.607143	0.607143	0.607143
35	0.413978	0.55914	0.596774	0.535714	0.535714	0.535714
40	0.413978	0.564516	0.580645	0.678571	0.678571	0.678571
45	0.413978	0.564516	0.596774	0.571429	0.571429	0.571429
50	0.419355	0.564516	0.602151	0.5	0.5	0.5
55	0.419355	0.575269	0.586022	0.571429	0.571429	0.571429
60	0.419355	0.575269	0.586022	0.571429	0.571429	0.571429
65	0.419355	0.575269	0.569892	0.642857	0.642857	0.642857
70	0.419355	0.575269	0.526882	0.571429	0.571429	0.571429
75	0.419355	0.575269	0.537634	0.571429	0.571429	0.571429
80	0.419355	0.575269	0.564516	0.535714	0.535714	0.535714
85	0.419355	0.575269	0.537634	0.607143	0.607143	0.607143
90	0.419355	0.575269	0.521505	0.571429	0.571429	0.571429
95	0.419355	0.575269	0.505376	0.75	0.75	0.75
100	0.419355	0.575269	0.473118	0.714286	0.714286	0.714286

Gray

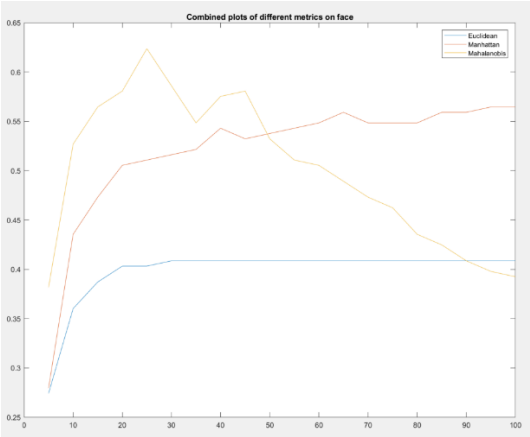

Figure: Accuracy of Faces using different metrics

	Face Accuracy			Subject Accuracy		
K	**Euclidean**	**Manhattan**	**Mahalanobis**	**Euclidean**	**Manhattan**	**Mahalanobis**
5	0.274193548	0.279569892	0.38172043	0.5	0.5	0.5
10	0.360215054	0.435483871	0.52688172	0.6071429	0.60714286	0.60714286
15	0.387096774	0.47311828	0.564516129	0.6785714	0.67857143	0.67857143
20	0.403225806	0.505376344	0.580645161	0.5714286	0.57142857	0.57142857
25	0.403225806	0.510752688	0.623655914	0.7142857	0.71428571	0.71428571
30	0.408602151	0.516129032	0.586021505	0.5	0.5	0.5
35	0.408602151	0.521505376	0.548387097	0.5357143	0.53571429	0.53571429
40	0.408602151	0.543010753	0.575268817	0.6428571	0.64285714	0.64285714
45	0.408602151	0.532258065	0.580645161	0.6785714	0.67857143	0.67857143
50	0.408602151	0.537634409	0.532258065	0.6428571	0.64285714	0.64285714
55	0.408602151	0.543010753	0.510752688	0.5714286	0.57142857	0.57142857
60	0.408602151	0.548387097	0.505376344	0.5357143	0.53571429	0.53571429
65	0.408602151	0.559139785	0.489247312	0.5	0.5	0.5
70	0.408602151	0.548387097	0.47311828	0.5357143	0.53571429	0.53571429
75	0.408602151	0.548387097	0.462365591	0.6071429	0.60714286	0.60714286
80	0.408602151	0.548387097	0.435483871	0.6071429	0.60714286	0.60714286
85	0.408602151	0.559139785	0.424731183	0.5357143	0.53571429	0.53571429
90	0.408602151	0.559139785	0.408602151	0.5714286	0.57142857	0.57142857
95	0.408602151	0.564516129	0.397849462	0.5357143	0.53571429	0.53571429
100	0.408602151	0.564516129	0.392473118	0.5357143	0.53571429	0.53571429

Observations: We can observe the following accuracy patterns of different metrics in different colour spaces using different K values.

Euclidean: As the number of features increases, the accuracy of recognizing the face initially increases and then remains constant.
Manhattan: As the number of features increases, the initial accuracy grows rapidly and then keeps on growing at a slower rate.
Mahalanobis: As the number of features increase, the accuracy increases for a certain period and then drops after a certain point.