CSE 555: Project Report

Face Recognition

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This Project involves recognizing human faces and classifying them using the training samples. Face recognition problem has been in the AI community for some time now and has seen many algorithm, proposed by different researchers with different scopes in mind. The tradeoff between accuracy and computational complexity must be taken into consideration when designing such systems.

Face recognition has many applications and it is a great research area to undertake. One of its applications is People tagging. With the increase of social media and networks online, picture sharing and processing is in high demand. Using this wealth of picture databases, face recognition and classification come in handy for users and makes the social network experience more pleasing. Facebook is known for running such algorithm and is being used widely.

Another application for Face recognition is for implementing image search. The ability to search for matching images is very useful especially for people working in photography and design.

One popular reason for pursing this research is for integrating security systems with face recognition. This has obvious gains as systems that are able to recognize people within a certain area and take certain actions would provide an enhanced security.

Algorithms

Eigenfaces and Fisherfaces were used in this project. Eigenface uses principal component analysis (PCA) to reduce the dimension. The new feature vectors are obtained by linear transformation using the weight that maximize the determinant of the scatter matrix of the projected samples. The eigenvectors used here are called Eigenfaces since they have the same dimension as the original pictures [1].

Fisherfaces uses class specific linear method for reducing the dimension which uses Fisher's Linear Discriminant (FLD). This is done by choosing the weight that maximizes the between-class and the within class scatter matrix. As the authors in [1] suggested, PCA is used first for reducing the feature space's dimension to N-c (no. of samples, no. of classes). Next, FLD is used for further reduction of the dimension.

Experiment

The image files used were obtained from the Yale face database. Each image was originally 195x231. These images were resized by a factor of 0.3 due to the high processing time of the original images.

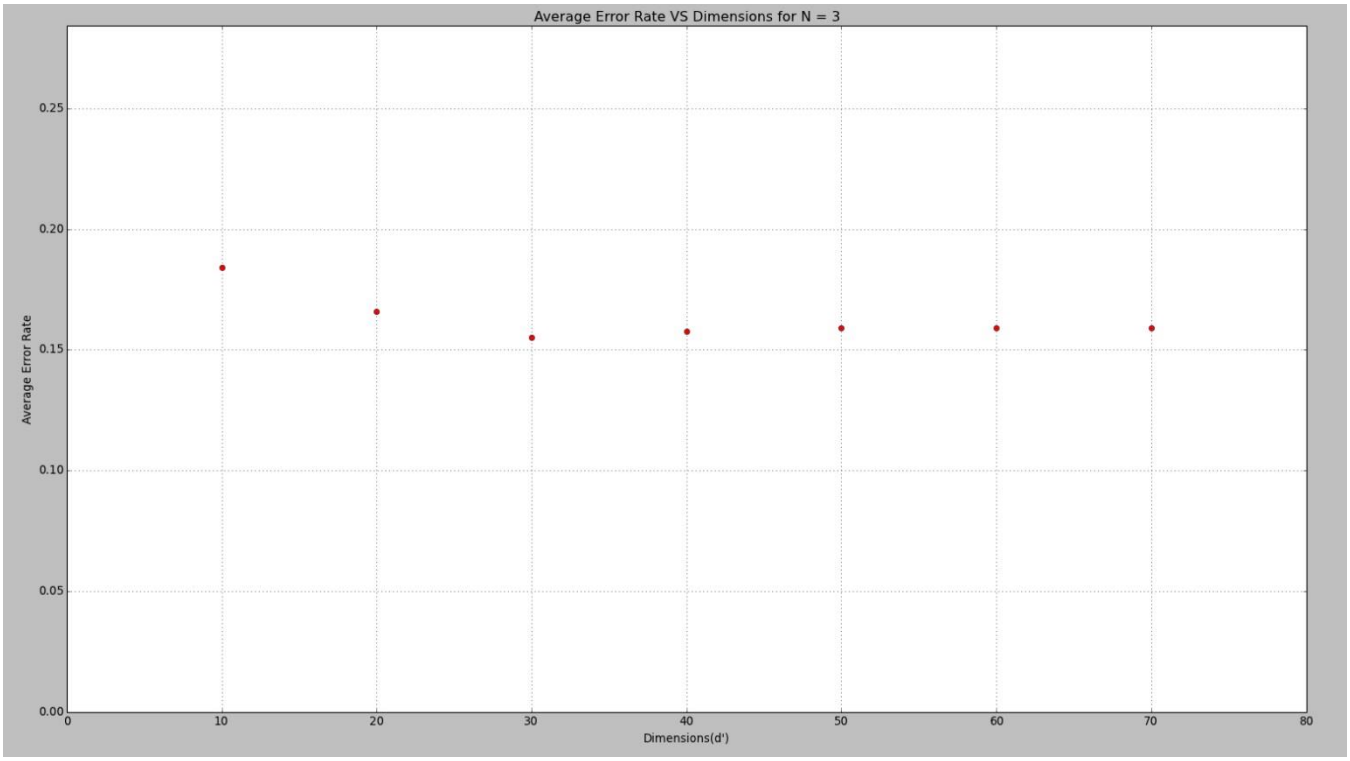
Below are the results for Eigenfaces.

N = 3	**p = [7, 5, 8]**	**N = 3 Experiment: 2**	**p = [3, 8, 4]**	N = 3 Experiment: 3	p = [10, 2, 5]
Ex 1			**Ex 2**		
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.2	10	0.191666667	10	0.175
20	0.15	20	0.2	20	0.183333333
30	0.133333333	30	0.191666667	30	0.15
40	0.133333333	40	0.183333333	40	0.15
50	0.141666667	50	0.183333333	50	0.15
60	0.141666667	60	0.183333333	60	0.15
70	0.141666667	70	0.183333333	70	0.15

N = 3 Exp: 4	p = [7, 3, 2]	N = 3 Exp: 5	p = [1, 11, 8]	N = 3 Exp: 6	p = [1, 5, 8]
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.183333333	10	0.183333333	10	0.208333
20	0.141666667	20	0.175	20	0.166667
30	0.141666667	30	0.183333333	30	0.141667
40	0.141666667	40	0.175	40	0.158333
50	0.141666667	50	0.175	50	0.166667
60	0.141666667	60	0.175	60	0.166667
70	0.141666667	70	0.175	70	0.166667

N = 3 Experiment: 7	p = [1, 2, 6]	N = 3 Experiment: 8	p = [6, 9, 11]	N = 3 Experiment: 9	p = [10, 1, 6]	N = 3 Experiment: 10	p = [10, 7, 3]
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.15	10	0.208333	10	0.133333333	10	0.208333
20	0.166667	20	0.2	20	0.1	20	0.175
30	0.158333	30	0.191667	30	0.091666667	30	0.166667
40	0.175	40	0.175	40	0.108333333	40	0.175
50	0.175	50	0.183333	50	0.108333333	50	0.166667
60	0.175	60	0.183333	60	0.108333333	60	0.166667
70	0.175	70	0.183333	70	0.108333333	70	0.166667

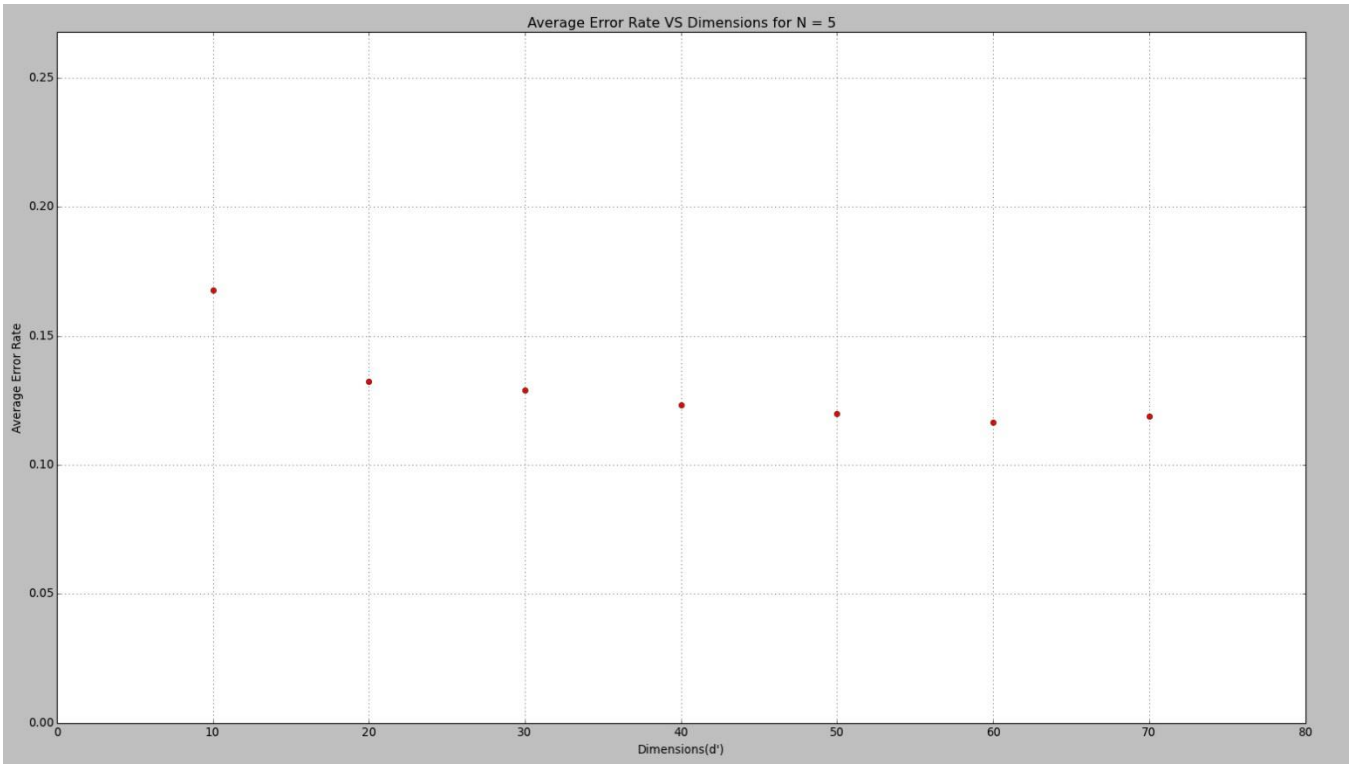
N = 3 Average	
D	**Average Error Rate**
10	0.184166667
20	0.165833333
30	0.155
40	0.1575
50	0.159166667
60	0.159166667
70	0.159166667



N = 5 Experiment: 1	p = [4, 8, 2, 6, 5]	N = 5 Experiment: 2	p = [7, 3, 5, 10, 11]	N = 5 Experiment: 3	p = [3, 11, 4, 6, 2]
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.166666667	10	0.177777778	10	0.133333333
20	0.144444444	20	0.144444444	20	0.111111111
30	0.122222222	30	0.133333333	30	0.111111111
40	0.122222222	40	0.144444444	40	0.111111111
50	0.122222222	50	0.122222222	50	0.111111111
60	0.111111111	60	0.1	60	0.111111111
70	0.111111111	70	0.111111111	70	0.111111111
N = 5 Experiment: 4	p = [10, 11, 9, 4, 6]	N = 5 Experiment: 5	p = [7, 1, 9, 5, 10]	N = 5 Experiment: 6	p = [1, 10, 6, 4, 9]
D	Error rate	D	Error rate	D	Error rate
10	0.188888889	10	0.144444444	10	0.122222
20	0.133333333	20	0.111111111	20	0.066667
30	0.144444444	30	0.111111111	30	0.077778
40	0.144444444	40	0.111111111	40	0.055556
50	0.144444444	50	0.111111111	50	0.055556
60	0.133333333	60	0.1	60	0.066667
70	0.133333333	70	0.1	70	0.066667

N = 5 Experiment: 7	p = [2, 8, 3, 7, 5]	N = 5 Experiment: 8	p = [7, 4, 1, 6, 2]	N = 5 Experiment: 9	p = [6, 3, 2, 5, 7]	N = 5 Experiment: 10	p = [2, 6, 10, 8, 5]
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.188889	10	0.122222	10	0.177777778	10	0.255556
20	0.144444	20	0.1	20	0.133333333	20	0.233333
30	0.144444	30	0.088889	30	0.122222222	30	0.233333
40	0.122222	40	0.077778	40	0.133333333	40	0.211111
50	0.122222	50	0.077778	50	0.133333333	50	0.2
60	0.122222	60	0.077778	60	0.133333333	60	0.211111
70	0.133333	70	0.077778	70	0.133333333	70	0.211111

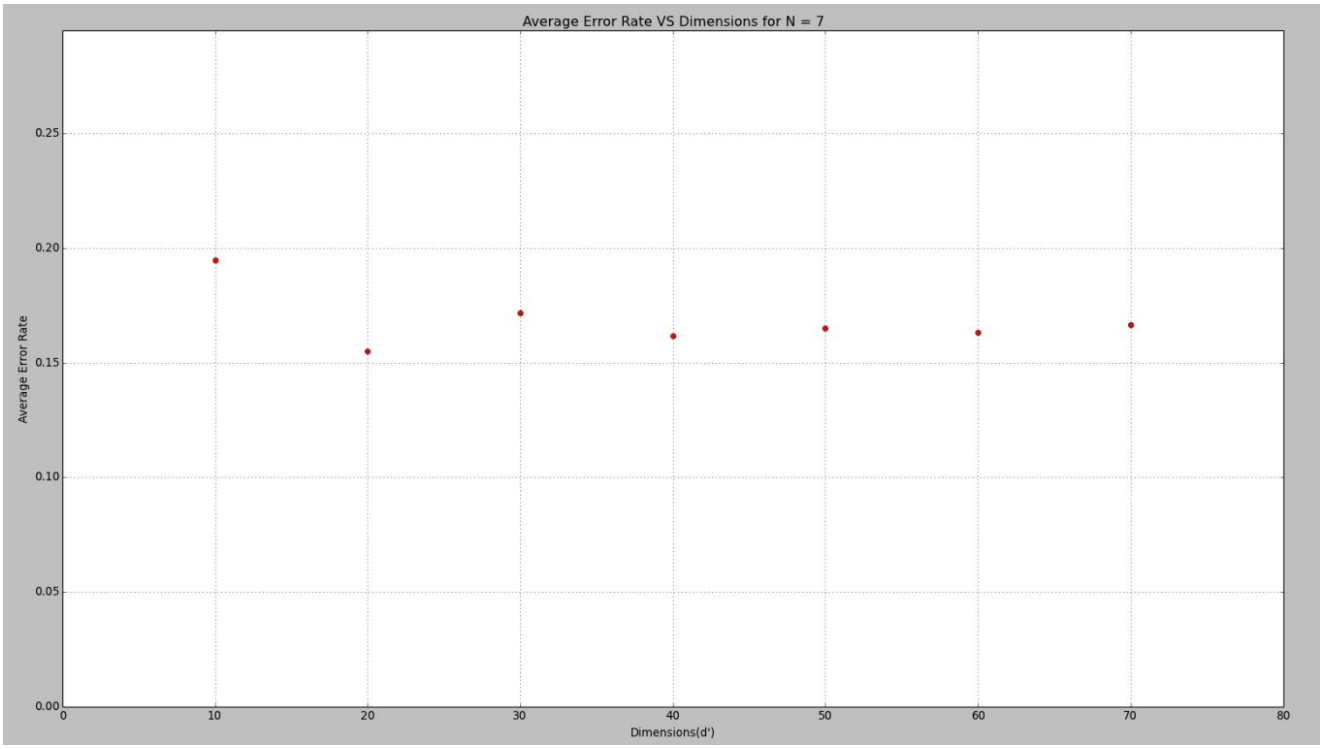
D	**Average Error Rate**
10	0.167777778
20	0.132222222
30	0.128888889
40	0.123333333
50	0.12
60	0.116666667
70	0.118888889


Average Error Rate VS Dimensions for N = 5
Average Error Rate
Dimensions(d')
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
80

N = 7 Experiment: 1	p = [3, 2, 11, 10, 5, 9, 6]	N = 7 Experiment: 2	p = [3, 1, 10, 2, 6, 11, 7]	N = 7 Experiment: 3	p = [6, 5, 3, 1, 7, 2, 10]
D		**D**		**D**	
10	0.316666667	10	0.133333333	10	0.166666667
20	0.283333333	20	0.1	20	0.1
30	0.266666667	30	0.15	30	0.1
40	0.266666667	40	0.15	40	0.083333333
50	0.266666667	50	0.133333333	50	0.1
60	0.266666667	60	0.116666667	60	0.1
70	0.266666667	70	0.116666667	70	0.1
N = 7 Experiment: 4	p = [2, 7, 1, 8, 5, 4, 9]	N = 7 Experiment: 5	p = [2, 5, 1, 3, 11, 6, 9]	N = 7 Experiment: 6	p = [11, 2, 10, 1, 9, 7, 5]
D		D		D	
10	0.016666667	10	0.25	10	0.15
20	0.016666667	20	0.25	20	0.1
30	0.016666667	30	0.266666667	30	0.15
40	0	40	0.25	40	0.116667
50	0.016666667	50	0.266666667	50	0.116667
60	0.033333333	60	0.266666667	60	0.1
70	0.033333333	70	0.266666667	70	0.133333

N = 7 Experiment: 7	p = [6, 10, 2, 11, 9, 8, 3]	N = 7 Experiment: 8	p = [11, 2, 5, 1, 10, 6, 7]	N = 7 Experiment: 9	p = [2, 9, 8, 10, 3, 5, 7]	N = 7 Experiment: 10	p = [2, 6, 10, 11, 9, 3, 4]
D		**D**		**D**		**D**	
10	0.333333	10	0.133333	10	0.25	10	0.2
20	0.3	20	0.1	20	0.166666667	20	0.133333
30	0.3	30	0.116667	30	0.183333333	30	0.166667
40	0.3	40	0.116667	40	0.166666667	40	0.166667
50	0.3	50	0.116667	50	0.166666667	50	0.166667
60	0.316667	60	0.1	60	0.166666667	60	0.166667
70	0.316667	70	0.1	70	0.166666667	70	0.166667

D	**Average Error Rate**
10	0.195
20	0.155
30	0.171666667
40	0.161666667
50	0.165
60	0.163333333
70	0.166666667

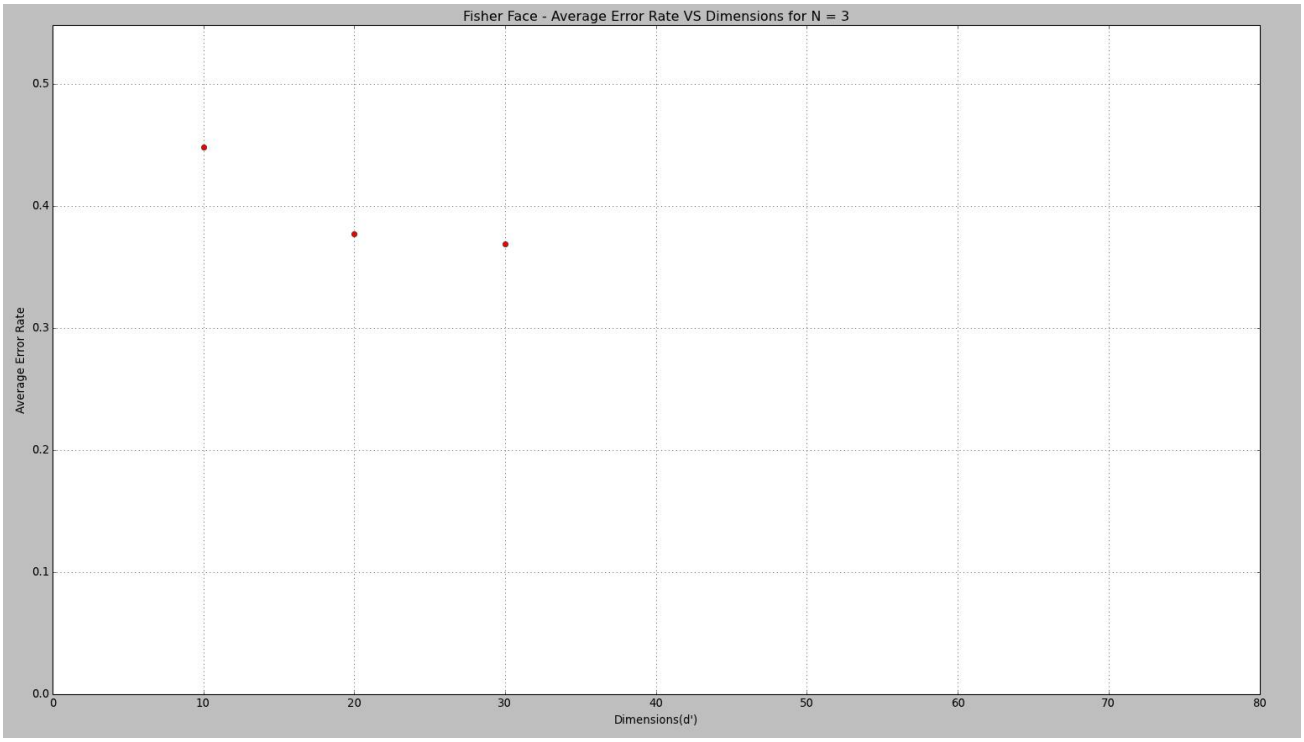

Average Error Rate VS Dimensions for N = 7
Average Error Rate
0.25
0.20
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
80
Dimensions(d')

The Following results are for Fisherfaces

N = 3 Exp: 1		N = 3 Exp: 2		N = 3 Exp: 3	
p = [6, 7, 1]		p = [7, 1, 2]		p = [1, 2, 5]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.416666667	10	0.425	10	0.366667
20	0.433333333	20	0.35	20	0.325
30	0.416666667	30	0.3	30	0.341667
N = 3 Exp: 4		N = 3 Exp: 5		N = 3 Exp: 6	
p = [4, 11, 8]		p = [3, 6, 7]		p = [10, 2, 6]	
D	Error rate	D	Error rate	D	Error rate
10	0.433333	10	0.441667	10	0.383333
20	0.341667	20	0.308333	20	0.366667
30	0.291667	30	0.3	30	0.375

N = 3 Exp: 7		N = 3 Exp: 8		N = 3 Exp: 9		N = 3 Exp: 10	
p = [7, 2, 11]	p = [3, 7, 11]			p = [5, 6, 11]		p = [3, 4, 11]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**	**`**	**Error rate**
10	0.516667	10	0.441667	10	0.533333	10	0.525
20	0.375	20	0.283333	20	0.5	20	0.491667
30	0.358333	30	0.291667	30	0.491667	30	0.525

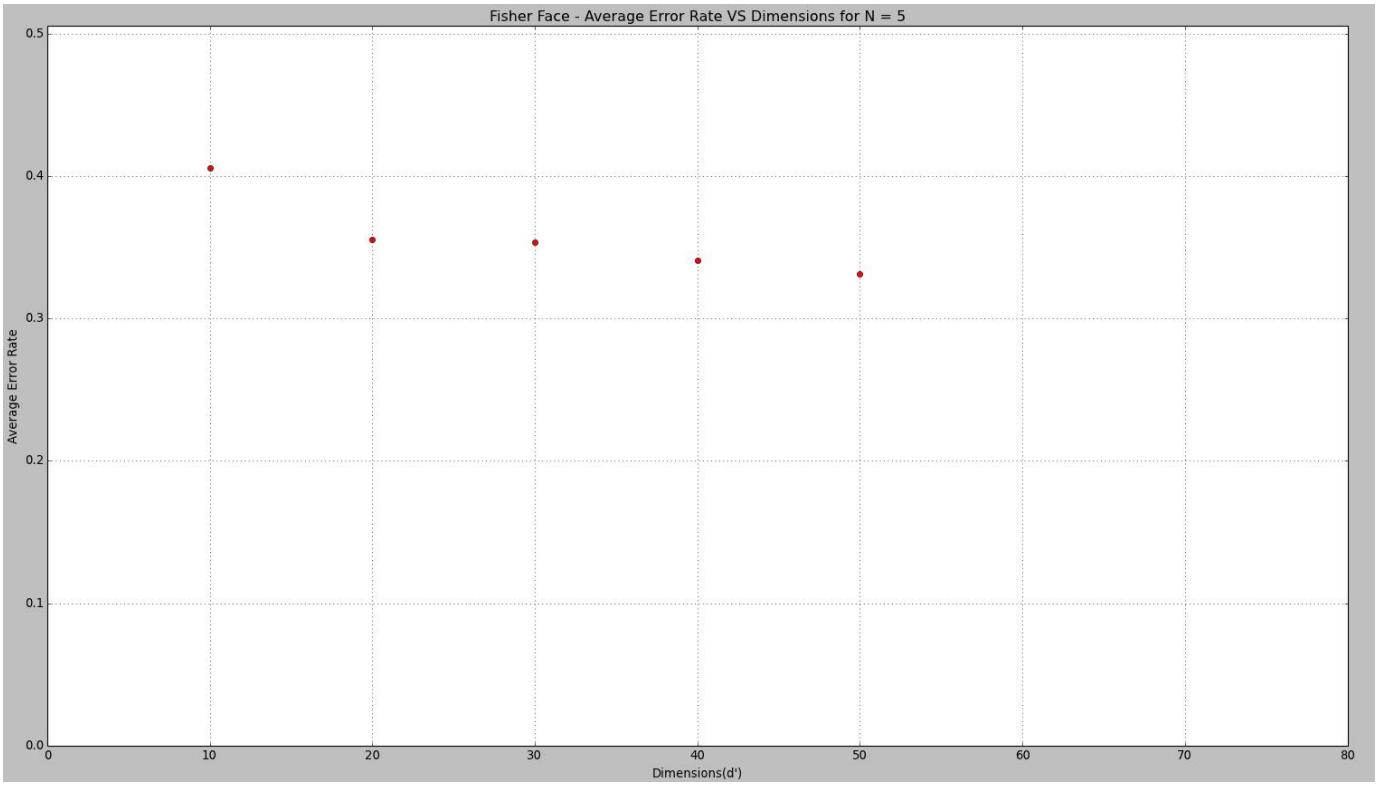
D	Average Error Rate
10	0.448333333
20	0.3775
30	0.369166667


Fisher Face - Average Error Rate VS Dimensions for N = 3
Average Error Rate
Dimensions(d')
0.0
0.1
0.2
0.3
0.4
0.5
0
10
20
30
40
50
60
70
80

N = 5 Experiment: 1		N = 5 Experiment: 2		N = 5 Experiment: 3	
p = [8, 4, 3, 7, 11]		p = [11, 2, 8, 3, 5]		p = [10, 4, 2, 9, 5]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.388888889	10	0.488889	10	0.322222
20	0.255555556	20	0.477778	20	0.3
30	0.244444444	30	0.444444	30	0.322222
40	0.244444444	40	0.422222	40	0.322222
50	0.222222222	50	0.433333	50	0.3
N = 5 Experiment: 4		N = 5 Experiment: 5		N = 5 Experiment: 6	
p = [5, 6, 10, 11, 1]		p = [10, 3, 8, 9, 6]		p = [9, 5, 4, 10, 2]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.488889	10	0.466667	10	0.322222
20	0.4	20	0.433333	20	0.355556
30	0.422222	30	0.455556	30	0.355556
40	0.411111	40	0.422222	40	0.355556
50	0.377778	50	0.422222	50	0.344444

N = 5 Exp: 7		N = 5 Exp: 8		N = 5 Exp: 9		N = 5 Exp: 10	
p = [2, 10, 8, 7, 5]		p = [9, 11, 10, 4, 5]		p = [7, 11, 1, 3, 8]		p = [2, 1, 7, 9, 5]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.444444	10	0.433333	10	0.366667	10	0.333333
20	0.355556	20	0.366667	20	0.344444	20	0.266667
30	0.322222	30	0.344444	30	0.355556	30	0.266667
40	0.322222	40	0.344444	40	0.322222	40	0.244444
50	0.3	50	0.333333	50	0.322222	50	0.255556

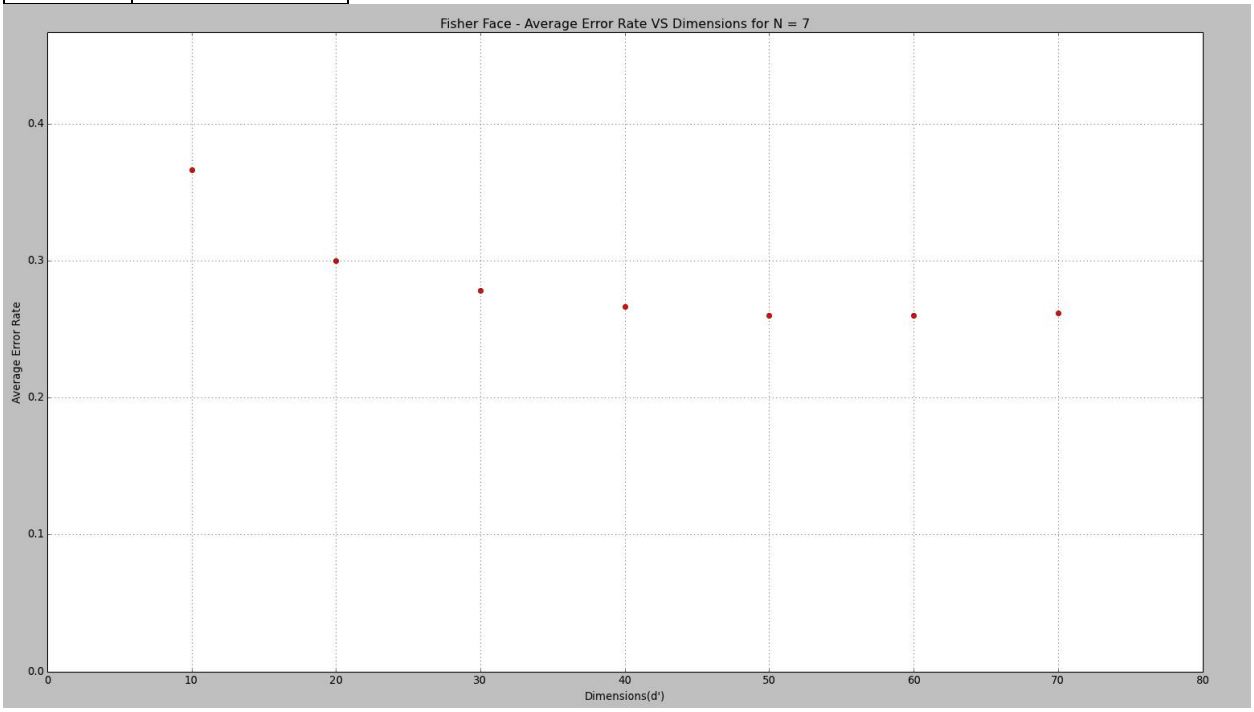
D	Average Error Rate
10	0.405555556
20	0.355555556
30	0.353333333
40	0.341111111
50	0.331111111


Fisher Face - Average Error Rate VS Dimensions for N = 5
Average Error Rate
Dimensions(d')
0.0
0.1
0.2
0.3
0.4
0.5
0
10
20
30
40
50
60
70
80

N = 7 Experiment: 1		N = 7 Experiment: 2		N = 7 Experiment: 3	
p = [4, 2, 7, 1, 11, 10, 8]		p = [11, 9, 8, 1, 10, 3, 7]		p = [5, 8, 4, 1, 6, 11, 9]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.266666667	10	0.416667	10	0.366667
20	0.2	20	0.3	20	0.316667
30	0.133333333	30	0.316667	30	0.3
40	0.116666667	40	0.283333	40	0.3
50	0.083333333	50	0.283333	50	0.283333
60	0.083333333	60	0.283333	60	0.3
70	0.083333333	70	0.283333	70	0.3
N = 7 Experiment: 4		N = 7 Experiment: 5		N = 7 Experiment: 6	
p = [3, 1, 5, 4, 11, 8, 6]		p = [11, 7, 8, 4, 5, 10, 2]		p = [5, 4, 10, 9, 11, 3, 6]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.25	10	0.25	10	0.433333
20	0.216667	20	0.216667	20	0.4
30	0.216667	30	0.216667	30	0.4
40	0.233333	40	0.2	40	0.4
50	0.25	50	0.2	50	0.383333
60	0.25	60	0.183333	60	0.383333
70	0.25	70	0.183333	70	0.4

N = 7 Experiment: 7		N = 7 Experiment: 8		N = 7 Experiment: 9		N = 7 Experiment: 10	
p = [3, 1, 10, 4, 9, 8, 2]		p = [8, 5, 1, 6, 7, 10, 11]		p = [5, 6, 2, 7, 9, 10, 3]		p = [4, 9, 6, 7, 10, 8, 3]	
D	**Error rate**	**D**	**Error rate**	**D**	**Error rate**	**D**	**Error rate**
10	0.433333	10	0.466667	10	0.516667	10	0.266667
20	0.316667	20	0.416667	20	0.4	20	0.216667
30	0.233333	30	0.383333	30	0.4	30	0.183333
40	0.233333	40	0.3	40	0.416667	40	0.183333
50	0.233333	50	0.3	50	0.4	50	0.183333
60	0.233333	60	0.3	60	0.4	60	0.183333
70	0.233333	70	0.3	70	0.383333	70	0.2

D	Average Error Rate
10	0.366666667
20	0.3
30	0.278333333
40	0.266666667
50	0.26
60	0.26
70	0.261666667



Reference

[1] P. Belhumeur, J. Hespanha and D. Kriegman, “Eigenfaces vs. fisherfaces: recognition using class specific linear projection,” IEEE PAMI, 1997