



Ain Shams University - Faculty of Engineering
Computer and Systems Engineering Department

Machine Vision Image Understanding Applied to Human Face Location and Identification

A Thesis

Submitted in Partial Fulfillment for the Requirements of the Degree
of the Master of Science in Electrical Engineering
(Computer and Systems Engineering)

006.37

M.N

Submitted by

محمد نابل
Mohamed Nabil MOUSTAFA

B.Sc. Electrical Engineering
(Computer and Control Section)
Ain Shams University, 1993

Supervised By

Prof. Dr. M. Adeeb R. GHONAIMY

Cairo-1997



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿ وَيسألونك عن الروح قل الروح من أمر ربي و ما أوتيتهم من العلم إلا قليلا ﴾

صدق الله العظيم

(الإسراء ٨٥)

Abstract

Mohamed Nabil Moustafa: Machine Vision Image Understanding
Applied to Human Face Location and Identification,
Ain Shams University, 1997

This thesis considers segmentation and identification of human faces from images with clutter. The segmentation developed uses a novel technique based on genetic algorithms (GAs) and principal component analysis (PCA). The later method is used to encode the statistical features of the face during the learning phase by projecting the training face image set on the eigenvectors of the covariance matrix. These eigenvectors constitutes the axes of the face space.

During the testing phase, the GA searches in the cluttered input image for the closest region, in euclidean means, to the face space built a priori. The GA chromosome encodes the coordinates of the rectangle framing the face, while the fitness function is inversely proportional to the distance from the face space.

The geometrical face features are then located using the same technique but referring to the features spaces which are the eyes, nose and mouth spaces. The recognition phase takes place to identify the located face image and its geometrical features.

The whole system components were implemented and integrated. The sensitivity analysis of the integrated system was tested on some common face databases with encouraging results.

Keywords

Computer vision, Pattern Recognition, Image Understanding, Principal Component Analysis, Genetic Algorithms, Face Recognition.

Summary

The aim of this work is to introduce a novel technique for face location in an input cluttered image. First, the thesis surveys relevant literature in the field of face segmentation and recognition. Second, it presents the work done in face recognition using Principal Component Analysis (PCA) method using either statistical or connectionist models. The PCA method is used to encode the statistical features of the face during the learning phase by projecting the training face image set on the eigenvectors of the covariance matrix. These eigenvectors constitutes the axes of the face space. A more comprehensive description follows by a set of experiments.

After a brief definition of a genetic algorithm, Chapter 3 introduces the proposed genetic algorithms for face location (GAFL) which searches in the cluttered input image for the closest region, in euclidean means, to the face space built a priori. The proposed GAFL architecture and its motivation are then described. Finally, results are presented through a series of detailed experiments on some common face databases with encouraging results

Some investigations done on the PCA approach are then described. These investigations tried to determine some necessary system parameters in an fully automated way. These parameters are the number of eigenfaces, the threshold of the distance from face space value and the threshold of the distance from face class value. A comparison between the GAFL and the distance from face space map method is held. The integration between the proposed GAFL (for face location) and the eigenfaces (for recognition) is introduced. The sensitivity of this approach is then studied against variation in size, illumination and rotation. The experimental results of the system sensitivity are presented.

Finally, Chapter 6 concludes the thesis, by summarizing the results obtained and indicating the future directions of face recognition.

Acknowledgments

I would like to express my sincere appreciation to Prof. Adeeb R. Ghonaimy for his valuable help and profound encouragement. I have enjoyed being his student.

I would like also to thank the professors and staff members of my department who helped me.

Special thanks to my wife for her valuable advice in preparing the manuscript and for being understanding and selfless.

Finally, I would like to thank my parents and my sister for their strong support during all my life.

Contents

1	Introduction	1
1.1	Human Face Processing	1
1.1.1	Applications	2
1.1.2	Problem Statement	2
1.2	System Components	3
1.3	Aim of this work	4
1.4	Thesis Organization	5
1.5	Summary of Related Work	5
1.5.1	Geometric Features Matching Methods	6
1.5.2	Templates Matching Methods	7
2	Face Recognition Using PCA	11
2.1	Introduction	11
2.2	EigenFaces Method	12
2.2.1	Introduction	12
2.2.2	System Description	13
2.2.3	Dimensionality Reduction	19
2.2.4	Face Location Using DFPS Map	20
2.3	Linear Autoassociator	22
2.3.1	Hebbian Learning	23
2.3.2	Widrow-Hoff Learning	24
2.3.3	Discussion	25
2.4	Experiments	25
2.4.1	Training	25
2.4.2	Testing	27

2.4.3	Face Location Using DFFS Map	34
2.5	Discussion	34
3	Proposed G.A. for Face Location	36
3.1	Overview of Genetic Algorithms	36
3.1.1	Population	37
3.1.2	Reproduction	37
3.1.3	Crossover	37
3.1.4	Mutation	38
3.1.5	Anatomy of a GA	38
3.2	Proposed Algorithm	38
3.2.1	G.A.F.L. Setup	38
3.2.2	G.A.F.L. At Work	42
3.2.3	Enhancements	44
3.3	Experiments	45
3.3.1	Training Set	45
3.3.2	Input Images	46
3.3.3	Procedure	46
3.4	Results	48
3.4.1	Conclusion	53
4	On the EigenFaces Method	54
4.1	Introduction	54
4.2	Materials	54
4.2.1	System Parameters	54
4.2.2	Receiver Operating Characteristic	55
4.2.3	Image Data Sets	57
4.3	Experiments	61
4.3.1	EigenValues	61
4.3.2	EigenVectors	61
4.3.3	Recognition ROC	63
4.3.4	Identification ROC	64
4.4	Results	66
4.4.1	Number of EigenFaces	66

4.4.2	Distance From Face Space Threshold	68
4.4.3	Distance From Face Class Threshold	69
5	Putting It Together	70
5.1	DFFS Map vs. proposed GAFL	70
5.2	Sensitivity Analysis	72
5.2.1	Conditions Variation	72
5.2.2	Using Gradient Images	72
5.2.3	Rotational Invariance	75
5.3	Views and Features Eigenspaces	75
5.3.1	View based eigenspaces	76
5.3.2	Eigenfeatures	76
5.4	System Integration	77
5.4.1	Multiscale Face Location using GAFL	77
5.4.2	Features Location using GAFL	82
5.4.3	Recognition System	84
5.5	Discussion	84
6	Conclusions	85
6.1	Summary of Results	85
6.1.1	Genetic Algorithms	85
6.1.2	Eigenfaces Variables Determination	86
6.1.3	Integration	86
6.2	Limits and Shortcomings	87
6.3	Future Work	87
A	Face Databases	89
A.1	M.I.T. Face Database	89
A.2	O.R.L. Face Database	91
A.3	Essex Univ. Face Database	91
B	Image Pre-Processing	95
B.1	Smoothing	96
B.1.1	Low Pass Filter	96
B.1.2	Median Filter	97

B.1.3	Averaging with limited data validity	98
B.2	Sharpening	98
B.2.1	High Pass Filter	98
B.2.2	High Boost Filter	99
B.2.3	Derivative Filter	100
C	Eigensystems	102