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Face recognition : a literature review

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ABSTRACT

As one of the most successful applications of image analysis, face recognition has recently received significant attention, especially in recent years. The reason for this trend is the wide range of commercial, real and law enforcement applications. The availability of feasible technologies for the recognition of face images acquired in an outdoor environment with changes in illumination and/or pose remains a largely unsolved problem. This paper provides an upto date survey of face recognition research. In addition, issues of illumination and pose variation are covered.

Introduction

Face recognition is done naturally by humans; however developing a feasible algorithm to do the same thing is difficult .Assume that we start with images to distinguish between different peoples. One class of methods presupposes the existence of certain features in the image Such as, eyes, nose, mouth and hair, and an algorithm is devised to find and characterize these features. A second class of methods also assumes that there are features to be found but does not predefine what these features are or how to measure them this class of methods is much less restrictive than the previous.

Algorithms can be categorized into two classes, image template based or geometry feature based. This image template based methods compute the correlation between a face and one or more model templates to estimate the face identity.

2D Face Recognition Approaches, Neural networks, Back propagation techniques Better for detection and localization than identification Feature analysis: Localization of features, Distance between features, Feature characteristics Graph matching: Construct a graph around the face Possible need for feature localization, Can include other data (color, texture).Eigen face :Information Theory approach, Identify discriminating components .Fisher face: Uses 'within-class' information to maximize class separation.

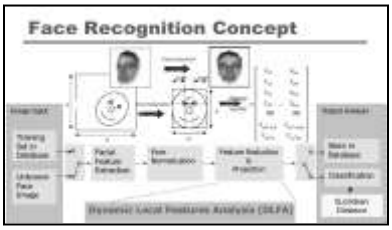

Fig 1- Face Recognition Concept[10]

In general face recognition concept has several stages Image input: it contains training set in database and Un known Face Image .form the unknown face Image the facial features are extracted, the extracted features are Normalized followed by feature reduction and Projection with the help of dynamic local feature Analysis finally the Output Analysis the result is stored in database the classification is done by the Euclidian Distance Metrics.

Based on the neural network-based classification algorithm, the face is represented by an "dynamic" edge analyzing the facial shape and texture and thus basing the comparison on up to 108 characteristics. Dynamic Local Feature Analysis ("DLFA") This technology locally uses the eigenface method for a few single parts of the face (e.g. eyes, nose, mouth) and additionally determines their geometric proportions to each other. Local Feature Analysis This technology re-constructs a face by superimposing a setof so-called "eigenface". The similarity of two facial images is determined based on the coefficient of the relevant eigenfaces.

Neural network based face detection

The face recognition methods include the Neural Network, the Fisher Face method, using infrared images and Eigen faces, view –based Eigen faces 3D model enhanced face recognition, and view-based and modular Eigen faces for Face Detection. All the methods are described below.

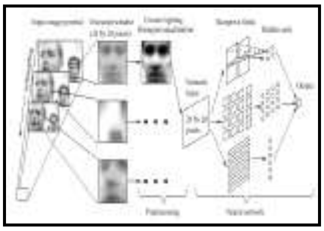

Fig 2- Neural Network Based Face Detection

Large training set of faces and small set of non-faces Training set of non-faces automatically built up: Set of images with no faces Every 'face' detected is added to the non-face training set .

Extraction of Facial Features for Recognition Using Neural Networks

Assigns a symmetry magnitude to each pixel, to create asymmetry map (right), Applying geometric constrains, locates

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regions of interest Several neural networks are trained using various back-propagation methods. The ensemble network results are used to classify features

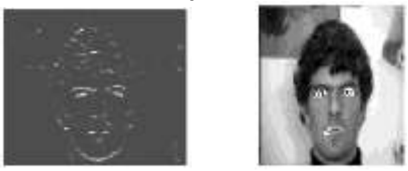


Fig 3 Extraction of Facial Features for Recognition Using Neural Networks

Face Recognition through Geometric Features

Uses vertical and horizontal integral projections of edge maps., The nose is found by searching for peaks in the vertical projection., Geometrical features used. Recognition performed by Nearest Neighbour. applicable for small databases, or preliminary step.

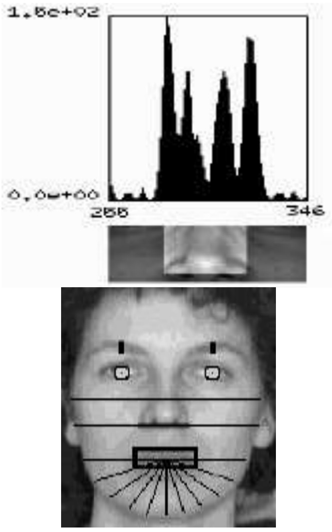


Fig 4 *Face Recognition through Geometric Features*

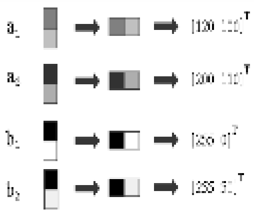
The eigen faced method

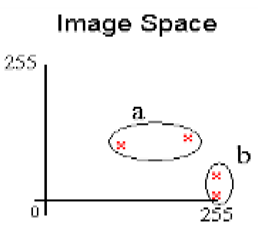
Eigen faces for Recognition

Use Principal Component Analysis (PCA) to determine the most discriminating features between images of faces. Create an image subspace (face space) which best discriminates between faces. Like faces occupy near points in face space. Compare two faces by projecting the images into faces pace and measuring the distance between them.

Image space

Similarly the following 1x2 pixel images are converted into the vectors shown.





Each image occupies a different point in image space. Similar images are near each other in image space. Different images are far from each other in image space. Applying the same principal to faces A 256x256 pixel image of a face occupies a single point in 65,536-dimensional image space. Images of faces occupy a small region of this large image space. Similarly, different faces should occupy different areas of this smaller region. The face can be identified by finding the nearest 'known' face in image space.

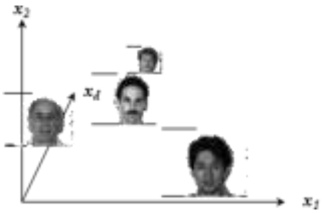


Fig 5 Image Space

However, even tiny changes in lighting, expression or head orientation cause the location in image space to change dramatically. Plus, large amounts of storage is required In Practice Align a set of face images (the training set) rotate, scale and translate such that the eyes are located at the same coordinates. Compute the average face image Compute the difference image for each image in the training set compute the covariance matrix of this set of difference images Compute the eigenvectors of the covariance matrix .

Fig 6 Examples of Eigen faces

The eigenvectors of the covariance matrix can be viewed as images.

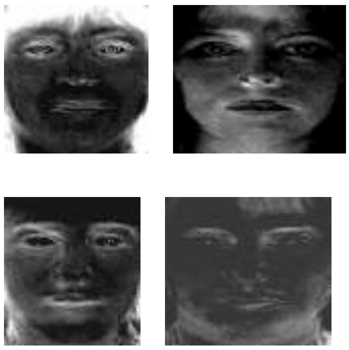
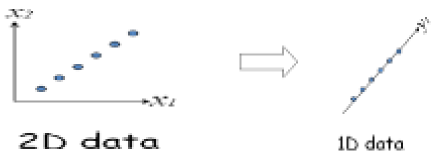


Fig 7 eigenvectors of the covariance matrix

These are the first 4 eigenvectors, from a training set of 23 images. Hence the name Eigen faces Dimensionality Reduction Only selecting the top M Eigen faces, reduces the dimensionality of the data. Too few Eigen faces results in too much information loss, and hence less discrimination between faces.



The Fisher Face Method

Eigen faces vs. Fisher faces: Recognition Using Class Specific Linear Projection Eigen faces attempt to maximize the scatter of the training images in face space. Fisher faces attempt to maximize the between class scatter, while minimizing the within class scatter In other words, movesimages of the same face closer together, while moving images of difference faces further apart.

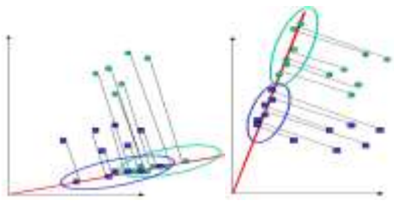


Fig 8 Fisher's Linear Discriminant

Attempts to project the data such that the classes are separated.

Disadvantages of Face Recognition

Not as accurate as other biometrics. Large amounts of storage needed. Good quality images needed .Problems: Lighting Difference in lighting conditions for enrolment and query. Bright light causing image saturation .Artificial colored light. Pose – Head orientation. Difference between enrolment and subsequent images .Image quality CCTV etc. is often not good enough for existing systems

Face Recognition: the Problem of Compensating for Changes in Illumination Direction Image representations used: Standard grey level, edge map, 2D Gabor-like filters, first and second derivative. Distance measures used: Point wise, regional, affine-GL, local affine-GL, log distance viewing conditions. Frontal, profile, expressions, lighting Missed-face .If the distance between two images of one face under different conditions is greater than the distance between two different faces under the same conditions. Results changes in lighting direction: Grey-level comparison 100% missed-faces other representations 20%~100% missed-faces changes in viewing angle: Grey-level comparison 100% missed-faces Missed -faces of all representations above 50%Changes in expression Smile Grey-level comparison 0% missed-faces Gabor-like filters reduced the accuracy to 34% even though it was good for the changes illumination Drastic Grey-level comparison 60% missed-faces Other representations decreased accuracy Lighting: Potential Solutions Controlled lighting Dominant light source Infrared images .

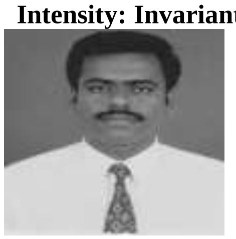
Face Recognition Using Infrared Images And Eigen Faces

Color normalization, Intensity normalization, Grey-world normalization, Comprehensive normalization, HSV – hue representation, Brightness and gamma invariant hue Filters, Edge detection2D Gabor-like filters First and second derivatives Comprehensive Color Image Normalization Apply intensity normalization, followed by Grey World. Repeat until a stable state is reached.

Hue that is invariant to brightness and gamma Apply a log transform to the RGBs. Gamma becomes multiplicative scalars and cancel. Taking the difference between color channel cancels the brightness. The angle of the resulting vector is analogous to the standard HSV Hue definition.

Fig 9 Examples of Lighting Correction

Original Image   Intensity: Invariant to light direction



Grey world:Invariant to coloured light

Comprehensive: Invariant to light colour and direction

HSV Hue: 'Colour' representation

BGi Hue: brightness and gamma in variant Pose

Potential Solutions Multiple enrolment at various orientations Increases FAR Increases required storage space Image representations that are invariant to pose Colour histograms3D model enhancement.

View-Based Eigen Faces 3d Model Enhanced Face Recognition

Use a generic 3D shape to estimate light source and pose affect in the 2D image. Compensate for the above to render a prototype image. Perform face recognition on the prototype image.

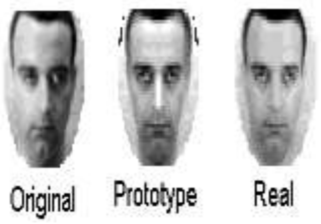


Fig 10 Face Recognition on the Prototype image

View-Based And Modular Eigen Faces For Face Recognition

Use several projections into face space. Each projection represents a different viewing angle. When comparing faces use all projections. Use the nearest to face space angle or just identify as the nearest known face across all projections.3D Facial Recognition Increase accuracy.

Removes pose and lighting problems. Enough invariant information to cope with changes in expression, beards, glasses etc Existing Approaches: profile matching. Surface segmentation matching. Point signature.

Self-organising matching.PCA. AURA – coming soon 3D surface too noisy for global surface matching. Take central and lateral profiles from the 3D surface. Compare 13 2D profiles.

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Fig 11 Automatic 3D Face Authentication

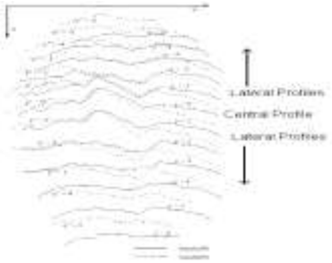

Fig 12 Description and Recognition of Faces from 3D

Data3D Data acquired by optical surface scanning. Eight fundamental surface types are defined: Peak, pit, ridge, valley, saddle ridge, saddle valley, minimal, flat. Facial surface is segmented into surface types. Facial features are manually localised by a user. Local regions are analysed for the surface type present. It is argued that faces can be distinguished by the surface types present in these local regions. No results are presented. Point Signature Each plot in the 3D surface is represented by its point signature. Place a sphere of radius r centred at point p. The intersection of the sphere and surface creates a 3D space curve C. This curve is projected such that its planar approximation is parallel to its normal, to make a new 3D curve C`.A point signature is the set of distances from the points on C to the corresponding points on C`, at intervals of B^{o} around the sphere Matching 3D Surfaces Point signatures are compared by taking the difference between each distance pairs in the two point signatures. All distance must be within a tolerance level for the point signatures to match.100% Accuracy achieved. But only tested on 6 people. Some Other Approaches .

3-D Human Face Recognition By Self-Organizing Matching Approach

Implemented on a massively parallel field computer with 16387 processors. A graph matching approach is used, by minimizing a fitting function by simulated annealing.

Application Areas [10]

Toy Intelligent robotic

Casino Filtering suspicious gamblers / VIPs

Vehicle Safety alert system based on eyelid movement

illegal immigrant detection;

Passport / ID Card authentication

Immigration/Customs

Government Events Criminal/Terrorists screening; Surveillance

Enterprise Security Computer and physical access control

Conclusion

Face detection is a both challenging and important recognition technique. Face detection is a challenging and interesting problem in and of itself. However, it can also be seen as a one of the few attempts at solving one of the grand challenges of computer vision, the recognition of object classes. The class of faces admits a great deal of shape, color, and variability due to differences in individuals, no rigidity, facial hair, glasses, and makeup. Images are formed under variable lighting and 3D pose and may have cluttered backgrounds. Hence, face detection research confronts the full range of challenges found in general purpose, object class recognition. However, the class of faces also has very apparent regularities that are exploited by many heuristic or model-based approach possesses one great advantage, which is its user-friendliness (or non-intrusiveness). In this paper, we have given an introductory survey for the face recognition technology. We have covered issues such as the generic framework for face recognition, factors that may affect the performance of the recognizer, and several state-of-the-art face recognition algorithms. We hope this paper can provide the readers a better understanding about face recognition, and we encourage the readers who are interested in this topic to go to the references for more detailed study methods or are readily “learned” in data-driven methods.

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