

An Overview of Face Recognition Algorithms and their Comparison with Zernike and SIFT

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ABSTRACT- Biometrics refers to measuring any human trait for various purposes. Face is also an important biometrics trait that can be measured and used for various functions. It can be utilized to affirm authenticity or check personality of a man. For measuring face certain algorithms are used. They extract features from face for measuring face. These extracted features fall in two categories – global and local features. Global features take into account the whole face but local features consider local characteristics of face such as the distance between eyes and nose. Various algorithms are used to extract these features from image. In this paper we will discuss regarding the different algorithms used for face recognition that are Scale Invariant Feature Transform (SIFT), Principal Component Analysis (PCA), Independent Component Analysis (ICA), Linear Discriminate Analysis (LDA), Zernike Moments (ZMs), Support Vector Machine (SVM), Elastic Bunch Graph Matching (EBGM), Convolutional Face Finder (CFF) etc. and compare them with Zernike moments and SIFT. Zernike moments extract global features from an image and SIFT extracts local features from an image. A combination of Zernike moments and SIFT provide a high accuracy rate in recognition.

Keywords: Enrollment, Face recognition, face verification, identification, Zernike moments.

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1. INTRODUCTION

In biometrics, various traits of human beings are used for recognizing a person. Each human being has a distinctive identity. It is the mostly used method by each individual to identify other individual at first glance. Essentially face recognition is a way to seek other image of face with matching features of one image. Face is one of the best traits to identify an individual because in face recognition it is not necessary that a person should be aware of that his/her face is used for recognition. It assumes an imperative part in security systems. It is used for authenticating a person. It is more beneficial than usage of password or token for authentication. It does not suffer from the fear of being forgotten, lost or stolen. Face recognition can be used to identify people. It can be used to control access in various security systems. It can be used for security purposes to ensure safety of people in public places. It is necessary to build a strong face recognition system capable to restrain the effect of illumination, scale, expression and pose variation.

Steps for face recognition:

Facial recognition process undergoes following stages:

Step 1: Obtain an image for recognition, either directly from a camera or from a database of images.

Step 2: Find the location of face in acquired image.

Step 3: Extract features from image. Features extracted can be local, global or both.

Step 4: Match the extracted features with the help of software.

Step 5: Declare decision that whether image is matched or not. If matched then identity of the image can be provided.

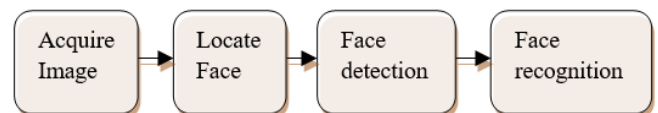


Figure 1: Steps for face recognition [18]

1.1 Working of a face recognition system

Practically working of every face recognition system is same. In the beginning, the process of enrollment is done. In enrollment registration of image of every new user is done into a database. For this image are usually passed through an algorithm that turns the selected image into a template. This template is stored in the database. The stored template consists of a very small amount of information as compared to the actual features. This template store features in the form of numbers. It is meaningful only to the biometric system that produced it. To identify any person, the system extracts appropriate features from an image, translate these features into a template by applying the same algorithm that the original template was computed with. Then the new template is compared with the database to determine if there is a match, and hence, either a verification or identification is done.

Face recognition scenarios can be classified into two types - Face verification (or authentication) and Face identification (or recognition).

1.1.1 Face verification

It is a one-to-one matching. It compares a query face image against a template face image whose identity is being claimed.

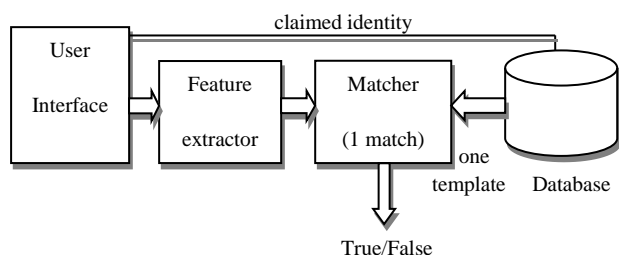


Figure 2: Verification [3]

1.1.2 Face identification

It is a one-to-many matching. It compares a query face image against all the template images in a face database to determine the identity of the query face. The test image is identified by finding the image in the database that has the maximum similarity with the test image.

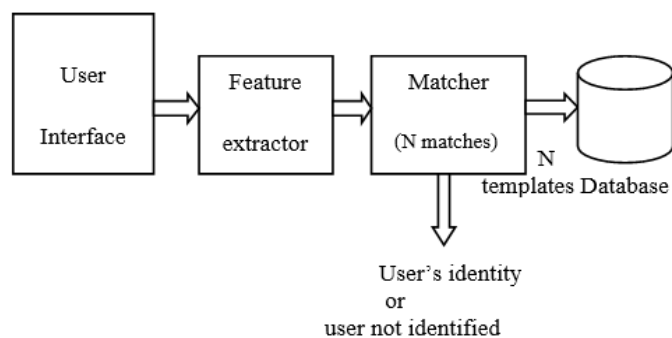


Figure 3: Identification [3]

1.2 Applications of face recognition

Face recognition offers many applications in various fields. Some of the common applications of face recognition are as follows:

Security Systems: Face recognition can be used in various security systems to check authenticity of a person. It can be used to control access and avoid unauthorized access to ensure security.

General identity verification: Face recognition can be used to verify the identity of a person. It can be used to identify newborns, criminals, employees etc.

Image database investigations: It can be used to investigate database of benefit recipients, licensed drivers, missing children, immigrants etc.

Identification: Face recognition can be used to identify a person. It can be used to approve presence of a authorized person without use of any token or password.

Surveillance: An application of it includes monitoring using CCTV cameras to avoid and identify any criminal activity at public places like streets, airports etc.

2. RELATED WORK

2.1 SIFT

Scale Invariant Feature Transform (SIFT) extracts local features from an image. It overcomes the challenges like variance in pose, scale, expression and translation in face recognition. Also it is partially invariant to illumination [9]. Features extracted using SIFT are resistant to image distortion and noise. It effectively detects feature points by applying filters in the scale space. SIFT extracts features from an image in four steps. The first step involves detection of potential points of interest by applying Difference of Gaussian (DoG) filters and computing maxima and minima of it. Second step involves discarding points of low potential. Third step assigns an orientation to each keypoint. Fourth step computes a local descriptor at each keypoint. It assigns a vector of dimension 128 distinctively to identify the neighborhood around each key point. With regards to coordinating element vectors of two pictures, a basic Euclidean separation measure is utilized. A component is viewed as matched with another element at the point when the distance to that component is less than a particular threshold T of the distance to the following closest element. At that point, the quantity of false matches can be lessened. At the point when utilizing the SIFT calculation for object recognition, each keypoint descriptor extracted from the query picture is matched freely to the database of descriptors extracted from all training pictures. The best match for every descriptor is found by distinguishing its closest neighbor (nearest descriptor) in the database of keypoint descriptors from the training pictures [9].

2.2 PCA

Principle Component Analysis (PCA) is one of the popular face recognition method that finds a set of basis images and represent faces as a linear combination of those images. It is a famous unsupervised statistical method. PCA is perhaps the most extensively used subspace projection technique for face recognition. It uses the pair wise relationship between the pixels of an image. PCA basis vectors are computed from a set of training images I . As a first step, the average image in I is computed and subtracted from the training images, creating a set of data samples. The main aim in PCA is to discover a "superior" set of basis images so that in this new basis, the image coordinates (the PCA coefficients) are uncorrelated, i.e., they cannot be linearly anticipated from each other. Notwithstanding, PCA can just separate pair wise direct dependencies between pixels. High-arrange dependencies will at present show in the joint distribution of PCA coefficients, and, in this manner, won't be appropriately isolated. The objective of PCA is to re-express the first information by lower dimension premise vectors in a substantially more effective way so that noise and repetition of the information be kept to least [13].

2.3 ICA

Independent Component Analysis (ICA) is a generally utilized subspace projection system that projects information from a high-dimensional space to a lower-dimensional space. ICA is a generalization of PCA [1]. It can be performed on image set in two methods. Method I treats the images as random variables

and the pixels as outcomes, while method II treats the pixels as random variables and the images as outcomes. ICA describes a generative model for the viewed multivariate data, which is regularly given as an immense database of tests. In the model, the data variables are thought to be immediate mixes of some dark unmoving variables, and the mixing structure is moreover dark. The unmoving variables are acknowledged non-gaussian and ordinarily free, and they are known as the autonomous parts of the watched data. These autonomous sections, also called sources or variables, can be found by ICA. ICA is remotely related to chief section examination and component examination. ICA is an altogether more viable procedure, of course, prepared for finding the central parts or sources when these awesome systems fail completely.

2.4 LDA

Linear Discriminant Analysis (LDA) is a statistical methodology for grouping tests of obscure classes by training tests with known classes. LDA permits target assessment of the hugeness of visual data in various components of the face for recognizing the human face. The LDA additionally furnishes us with a little arrangement of components that convey the most applicable data for classification purposes. LDA strategy conquers the constraint of Principle Component Analysis technique by applying the direct discriminant model. This model tries to amplify the proportion of determinant of the between-class scatter matrix of the anticipated examples to the determinant of the within-class scatter matrix of the projected samples. It scans for those vectors in fundamental space that best separate among classes (as opposed to those that best depict the information). It extracts global features from the image. LDA makes a linear combination of those which yields the biggest mean contrast between yearning classes. It bunches the pictures of the same class and separate pictures of various classes.

2.5 Zernike Moments

Zernike moments are geometric-based moments that use the global data in a picture for extracting features from face. It extracts the features generated by transforming the input image on a complex set of Zernike functions [15]. For the calculation of ZMs, at first the basis function of the ZMs is characterized by figuring their radial polynomials. From that point, the input picture is anticipated onto this assessed basis function of the ZMs. ZMs are seen to be one of the best shape descriptors in light of their numerous attractive qualities. The noticeable attributes incorporate orthogonal kernel functions that guarantee least data repetition between moments, rotation invariance showed by magnitude of ZMs, extent of easily accomplishing translation and scale invariance and robustness to picture noise. Further, the phase coefficients of ZMs of the original picture and that of the pivoted picture might be used to estimate angle of rotation between them. The features extracted using Zernike moments at high order are invariant to expression changes. At the point when the Zernike snippets of the picture are suitable for a substantial number of terms, then the recreation of the input image function can be accomplished with high precision. The reproduction relies on upon the quantity of Zernike polynomials included. The attractive feature of Zernike

polynomials is the distinguishable nature of their orthogonal radial and angular components.

2.6 SVM

Support Vector Machines is an exceptionally successful strategy for general purpose pattern recognition. SVMs fit in with the class of greatest margin classifiers. They perform pattern recognition between two classes by finding a choice surface that has most extreme distance to the nearest points in the training set which are termed support vectors. Naturally, given an arrangement of points having a place with two classes, a SVM finds the hyperplane that isolates the biggest conceivable fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane. This hyperplane is termed as the optimal separating hyperplane (OSH) [11]. SVM can be used for identification as well as verification. Verification is in a general sense a two class issue. A verification algorithm is introduced with a picture P and an claimed identity. Either the algorithm acknowledges or rejects the case. A direct technique for building a classifier for individual X, is to feed a SVM algorithm a training set with one class comprising of facial pictures of individual X and the other class comprising of facial pictures of other individuals. In identification proof, there is a gallery of m known people. The algorithm is introduced with a probe p to be recognized. The initial step of the identification algorithm calculates a likeness score between the probe and each of the gallery pictures. In the second step, the probe is recognized as individual j that has least similitude score.

2.7 EBGGM

Elastic Bunch Graph Matching is implemented utilizing Elastic Bunch Graph Matching (EBGGM) calculation. It utilizes cosine comparability as its coordinating measure rather than a classifier for recognition. It makes utilization of facial components like fudcial points to separate between faces. It is harsh to variety in facial expressions, illumination and postures on frontal and $\frac{3}{4}$. Gabor wavelet is a complex Gaussian sinusoid which forms the basis of EBGGM algorithm. It helps in separating the features of each face. It yields a steadier representation of face features. The fundamental thought of EBGGM is to find and extract local facial components, for example, eyes, noses and mouth corners, for face matching. The geometric areas of the facial components are represented as a face graph. EBGGM calculates the closeness score between two face pictures by contrasting their EBGGM templates. It has been demonstrated that the validation performance of EBGGM depends altogether on how exact facial elements are found. The features utilized as a part of EBGGM algorithm are the wavelet changes of the original information, which represent to the prominent components of faces. Some component points are extracted after performing the Gabor wavelet change (GWT), and these component focuses are utilized as a part of the correlation and recognition process, rather than the original picture [6].

2.8 CFF

Convolutional Face Finder (CFF) is based on Convolutional Neural Networks (CNN). CNN are capable bioinspired various

leveled multilayered neural systems that join three architectural thoughts to guarantee some level of movement, scale, and distortion invariance: local receptive fields, shared weights, and spatial subsampling [2]. Diverse architectures of convolutional systems have been utilized effectively as a part of numerous troublesome applications, for example, handwriting recognition, machine-printed character recognition, and face recognition. It comprises in a pipeline of convolutions and subsampling operations. This pipeline performs automatic feature extraction in picture territories, and classification of the separated components, in a solitary integrated plan. The primary point of preference of the CFF calculation is that the aftereffects of the subsampling layers go through a hyperbolic tangent capacity, in this manner decreasing the danger for normal issues of fixed-point calculations, for example, arithmetic dynamic extension and saturation. Each Convolutional Neural Network consists of a number of layers layers, with the exception of the information plane (retina) that gets a picture zone to be named face or nonface. Layers contain an arrangement of planes where progressive convolutions and subsampling operations are performed. Since every layer basically performs parallel convolutions of little size parts, for each convolution, an expansive part of the calculation is in basic between two neighboring retina windows in the info pictures. This repetition is actually eliminated with by performing the convolutions relating to every layer on the whole info picture without a moment's delay. The general calculation comprises in a pipeline of convolutions and nonlinear changes over the whole pictures. At each level of the pipeline, full picture convolutions and nonlinear changes of little size kernels can be effortlessly performed in parallel. These standard operations can be actualized specifically on standard picture handling equipment sheets, permitting low-cost near real-time applications.

Comparison

Combination of Zernike moments and SIFT help to provide high accuracy in face recognition. They are resisted to variance in pose, expression, scale and partially to illumination. They provide robustness to noise in an image.

Table 1: Comparison of different algorithms

s. no.	Algorithm	Database	Recognition rate	Advantage	Disadvantage
1	SIFT	MORPH album 2 FG-NET	83.9	Age-invariant face recognition	It fails when encounters large pose changes
2	PCA	AR-Faces	70	Reduce dimensionality	Class separability remain same
3	ICA	FERET	89	Exploits higher order statistics	N/A
4	LDA	ASU	84.44	Reduce dimensionality while	Not applicable for non-linear problems

				preserving class discriminatory information	
5	Z_NN	Face Pix Database	97	Pose variations and high performance rate	N/A
6	SVM	ORL	98	Provide a good out-of-sample generalization	Lack of transparency of results
7	EVM	ORL	96.67	Insensitive to variations in face position, facial expression	Very sensitive to lightening conditions
8	CFF	FRGC version 2	80.3	Trained to automatically derive all parameters	N/A

3. CONCLUSION

Many algorithms are available for face recognition. Each algorithm offers a specific recognition rate. But a combination of Zernike and SIFT offers a high recognition rate. They can be used for recognition against change in pose, scale and expression in an image. In future work response time may be increased and different classifier can be use with Zernike Moments.

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