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Adaptive Analysis of Different Methodologies for 2D and 3D Face Recognition Framework

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Abstract: **As we all know that Face recognition are important issues in computer vision. A lot of researches are going on since last two decades. Face recognition is one of the challenging tasks. The human face plays an important role in our day to day life, for communicating people's identity. In this paper we have studied about various methodologies used for 2D and 3D face recognition and face identification. Also we have studied advantages and disadvantages of different methodologies. In this paper we also proposed an algorithm for recognizing 3D face images, which exploits the feature of principal component analysis and eigenfaces. We are trying to give an idea of the state of the art for 3D face recognition technology. We are trying to improve efficiency and recognition rate also proposed an algorithm for recognizing 3D face images which exploits the feature of principal component analysis and eigenfaces. We are trying to give an idea of the state of the art for 3D face recognition technology. We are trying to improve efficiency and recognition rate.**

Keywords: Eigen Face, Elastic Bunch graph mapping, Face recognition technique, LDA, PCA, 3D Model.

I. INTRODUCTION

The face is the main centre of attraction in the society. They are inherent to human interaction, plays major role in communicating identity and emotions. A human can remember thousand of faces whole life and recognize known faces possibly even after long duration. This skill is quite powerful, even though large changes in the physical appearance, expressions, aging and confusion such as glasses, beards or changes in hair style [1]. A facial recognition system is used for identifying or verifying a person from a digital image. A facial recognition system is already used in every day authentication application like passport identification, health- card system, driving license system, ATM, booking stations, surveillance operations. It can be compared to other biometrics like fingerprint or eye iris recognition system. There are various biometric features which can be used to identify human like fingerprint, palm print, hand geometry, iris, face, speech, gaits, signature etc. But the problem was they require active cooperation of person whereas face recognition is a process does not require active cooperation of person. Therefore, face recognition is much more beneficial as compared to the other biometrics. Face recognition has a high identification or recognition rate of greater than 90% for large face databases.

Face recognition is the process of identifying an already detected face .It can be known or unknown, in other words we are identifying the person exactly who it is from our enrolled user database? Face recognition has two main tasks: verification and identification [1, 24, 25]. Face verification means a one to one match that correlate a face image against a template face image whose personality being matched. Face identification means a one to N problem that match a query face image against available image templates in a face database.

A. Basic of face recognition

The face recognition and detection are performed together. Previously for recognizing 2D faces following steps are followed:
Step I: Face detection
Step II: Face Alignment
Step III: Feature extraction
Step IV: Feature matching from database of enrolled users

In face recognition system the first step is to detect the face in an image. As we know faces decompose into 4 main organs eye, nose, mouth and eyebrow. Aim of face detection is to recognize whether there are any faces in the image or not. If the face matches, then it returns the location of image and amount of the each face matches. Face detection is a challenging task due to facial expression, occlusion, and image orientation. In second step face alignment is done and in third step feature extraction is used to find a specific representation of the data that focus on relevant information. Normally a face image is represented by a high dimensional vector containing pixel values. In fourth step feature matching is done to match the input face image or video from the available set of records or database of enrolled images with face ID. 2D Face recognition system process flow is shown in figure 1.

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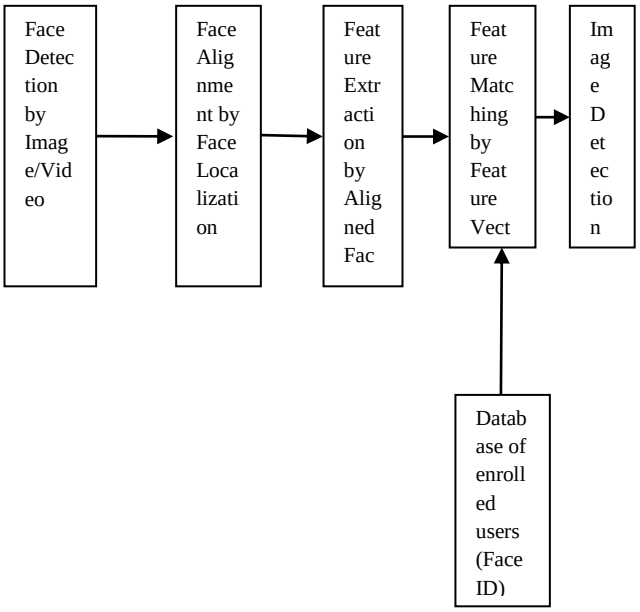

Fig.1 2D Face recognition system

A number of face recognition algorithm already introduced by different authors. It can be classified into two types: Pose-dependent and pose-invariant as shown in figure 2.
Pose dependency is further classified into viewer centered image and object centered image. Further these are classified into three approaches for face recognition:

a) Feature based approach: In this approach the local features like nose, eyes are partitioned and they can be used as input in face detection to simplify the task of face recognition.
b) Appearance based approach: In this approach face recognition is performed by taking whole face as input. For example LDA, PCA.
c) Hybrid approach: This approach is the combination of feature based and appearance based approach. In this approach both local and whole face is used as the input to face detection system. For example EGBM

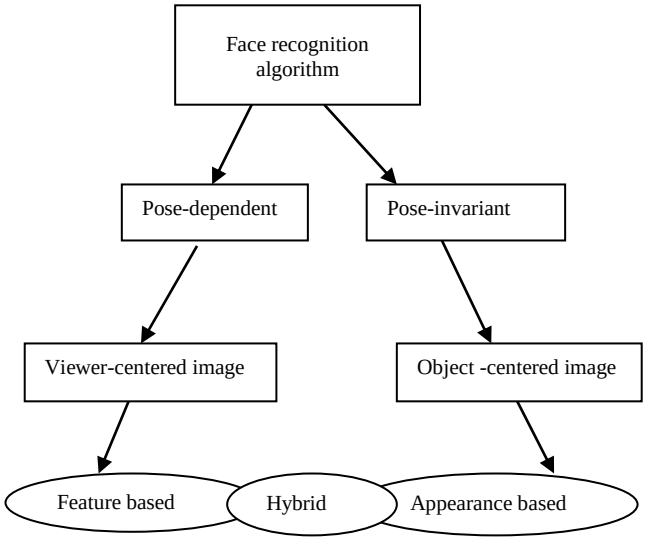

Fig 2: Types of Face recognition algorithm

There are some drawbacks of 2D face recognition. In 2D face recognition system performance is dependent on image capture conditions like lighting conditions, head orientation, image quality, facial expression, partial occlusion.

Nowadays, 3D face recognition technology is used to improve the face recognition rate. One of the benefits of 3D face recognition system is that it is not affected by light intensity. This technique can be used to recognize a face from a range of viewing angles [24, 25]. By using this technique facial recognition improves hugely.3D face recognition is enhanced with the help of experienced sensors capturing better 3D face image. We can generate 3D face models by using new 3D cameras which allows to use sub second generation of faces.

In 3D face model we have benefit of geometric depth information whereas 2D face model is based on color and texture. 3D face recognition is invariant to head rotation, camera distance and ability to rotate face model in 3D space. 3D face recognition system is shown in figure 3.

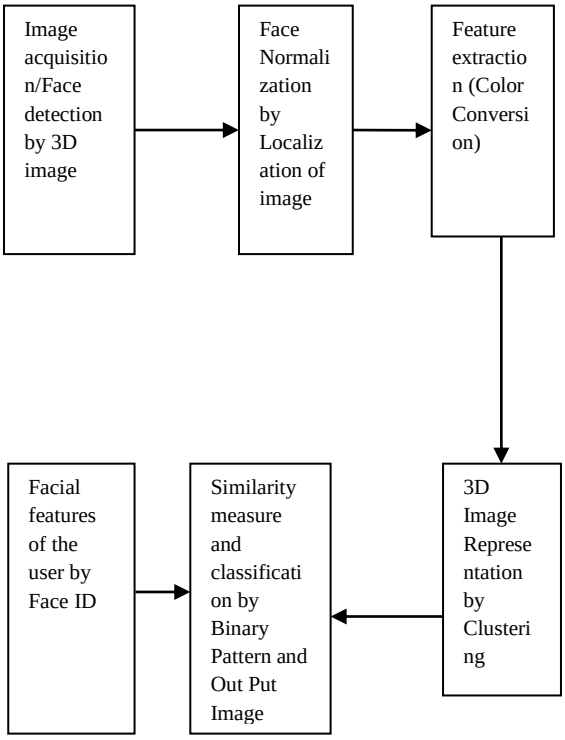

Fig.3 3D Face recognition system

As shown in figure 3 first step is image acquisition or image detection in which we detect the main organs of face that is eye, nose, mouth, and eyebrow. We also find out the keypoints or landmarks to localize the face image. In second step face normalization is done like color conversion, image enhancement, filtering, registration etc. In third step feature extraction is done like clustering, normalization, subspace learning and quantization to find feature vectors. In fourth step 3D image representation is done like binary patterns, key points, descriptors orientation, histogram wavelets etc. In fifth step similarity measure and classification is done to match facial ID from the available facial feature of the user.

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II. METHODOLOGY UESD FOR FACE RECOGNITION

We have studied 18 different techniques for face recognition, their advantage and their disadvantages which are used by different authors in different research paper as discussed below

1. Eigen face
2. Neural Network
3. Fisher faces
4. Elastic bunch graph matching
5. Template matching
6. Geometrical feature matching
7. Principal Component Analysis(PCA)
8. Independent Component Analysis(ICA)
9. Linear Discriminant Analysis(LDA)
10. Evolutionary Pursuit(EP)
11. Kernel methods
12. Trace transform
13. Active Appearance Model(AAM)
14. 3D morph able model
15. Bayesian Framework
16. Support vector Machine(SVM)
17. Hidden Markov Model(HMM)
18. Video based face recognition algorithm

1. Eigen face

The Eigen face method is one of the techniques for face recognition. Karhunen-Loeve is one of the eigenfaces techniques which use Principal Component Analysis (PCA)[1]. The method is used for dimensionality reduction. Mathematically, we can say that Eigen faces are the principal components which divide the face into feature vectors. We can obtain feature vector information from covariance matrix. Eigenvectors are used to compute the diversity between multiple faces. The faces are distinguished by the linear combination of maximum Eigen values. Each face can be expressed as a linear combination of the eigenfaces. The perfect M Eigen faces define an M dimensional space, which is called as the "face space". Principal Component Analysis is also used by L. Sirovich and M. Kirby to efficiently represent pictures of faces [7]. Limitation is that they are sensitive to lightening conditions and the position of the head. Eigenvectors and eigenvalues are time consuming .The size and location of every face image must remain similar [14].

2. Neural Network

Neural networks (NN) are widely applicable in character recognition, object recognition, robot driving, and pattern recognition problem [1, 9]. Feasibility of training a system to capture the complex class of face patterns neural network is used in face recognition. NN are non-linear in the network so it is extensively used for face recognition. This technique is more efficient as compared to PCA [9].It is applicable in media technology. It a challenging task to use NN for face recognition because it is tough to recognize whether face image matched or not. The drawback of NN is that it is more accurate when number of classes is small. As the class size increases recognition rate decreases and it become more complex.

2. Fisher faces

A Fisher face is a most widely used method for face recognition. These techniques are derived from Fisher Linear Discriminant (FLD) and are similar to eigenfaces but are more advanced and are based on appearance method. It is a classical technique first developed by Robert Fisher in 1936[34].This is better as compared to eigenfaces because we can classify the training set to deal with different people and different facial expression [1,5]. Fisher faces technique is more invariant to light intensity. The drawback is that it is more complex to solve the projection of face space. In this more processing time is required in recognition as compared to peter eigenfaces [14].

3. Elastic Bunch graph matching

In this technique we calculate a set of features for recognizing faces based on data structure known as a bunch graph. This technique is quite different from eigen faces and fisher faces [1]. This automatically locates the fudicial point like eye, ear, nose, mouth etc. to identify the face based on elastic bunch graph. In this technique we compare graph with images and generate new graphs. The advantage of this technique is that if any feature is missing or changed it will identify the people. This technique is used to recognize face upto 22 degree of rotation [25]. The drawback of this technique is that it is sensitive to lightening condition. A lot of graph we have to put manually to recognize face and recognition rate decreases due to light intensity increases [16].

4. Template Matching

Template matching is a feature based approach used for finding small parts of an image which match template image [25]. In this technique we can exploit other face templates from different point of view to identify single face. Mainly, grey levels that match the face image can also be handled in appropriate format. It uses four template features face, eye, mouth, nose and selecting the entire set [1, 25]. The template matching algorithm is a practical and simple approach technique and achieves high recognition rate. The advantage of this approach is that it is easy to implement as compared to other techniques. Complexity occurs only during the extraction of template. It is a simple technique having high recognition rate .It is applicable in face recognition and in medical field like X-Ray [25].The drawback is that it is costly and cannot be easily processed.

5. Geometrical feature matching

This technique is based on calculation of a set of geometrical features from the image of a face. The complete structure can be explained by a vector which shows the position and size of the main facial features like outline of face, eye, eyebrow, mouth [1]. In this technique face image is segmented into multiple facial geometrical domains like image orientation and image space at various scale. This technique is based on measured distance between various features. This is helpful when we are dealing with large database [25]. The drawback is that in automated face feature location algorithm computation time is high and rate of recognition is low.

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6. Principal Component Analysis(PCA)

PCA was first invented by Karl Pearson in 1901.This technique is derived from Karhunen-Loeve's transformation (KLT) [24, 25]. Kirby and Sirovich were among the first to apply principal component analysis (PCA) to face images. It is a statically procedure and used to find out lower dimensional subspace whose basis vector corresponds to the maximum variance direction in the original image. It means that if suppose a training set is given and an s-dimensional vector representation of each face is given than, by using PCA we can find out t-dimensional subspace such that t<<s. The PCA basis vectors are defined as eigenvectors of the scatter matrix .It is mostly applied as a tool in exploratory data analysis and for making predictive models. It is applicable in neuroscience and non inverse linear problem. It is also used for dimensionality reduction but drawback is that it is sensitive to lightening.

7. Independent Component Analysis(ICA)

This technique is, a generalization of PCA (principal component analysis), used to minimize second order and higher order dependencies in the input data [24, 25]. ICA can also be used to create feature vectors that uniformly distribute data samples in subspace. The technique tries to find the basis through which the data are statically independent.ICA was operated on face image in the FERET database under two different architecture: first architecture uses statically independent basis images, means in this architecture images are taken as random variables and pixel as outcomes.

. Second architecture uses factorial code representation of faces in which pixels are taken as random variables and the images as outcomes.

8. Linear Discriminant Analysis(LDA)

This technique is a generalization of Fisher's linear discriminant [24, 25, 26]. It is used in pattern recognition, machine learning, and statistics to compute features that separates two or more classes of objects or events. LDA is related to ANOVA (analysis of variance) and PCA (principal component analysis), which tries to express one dependent variable as a linear combination of other features. It reduces the limitation of PCA by applying linear discriminant criteria. LDA works when the evaluation made on independent variables for each observation are continuous quantities. It is applicable in statistics, pattern recognition and machine learning to find a linear combination of features. But the drawback is that it may face the small sample size problem. When the small sample size problem arises, the within-class scatter matrix becomes singular. Therefore, it become complex to implement.

9. Evolutionary Pursuit(EP)

This technique is used for image encoding and classification [24, 25, 27]. It is a specific kind of genetic algorithm (GA).It projects the original image into lower dimensional lightened principal component analysis space. It has optimal basis for the dual purpose of data compression and pattern classification. It is also used for face recognition. In this technique recognition rate is improved as compared to PCA(eigenfaces).It has better generalization abilities as compared to Fisher linear discriminant(Fisher faces).In this technique challenging task is to increase the generalization ability of the learning machine.

10. Kernel methods

This technique is used in machine learning and pattern analysis. It is a generalization of linear methods. In pattern analysis we study about clusters, ranking, principal component, correlation, classifications in datasets [24, 25, 28]. Whereas kernel methods require only a user specified kernel, it means a similarity function over pairs of data point. These techniques are based on convex optimization or eigen problems. These techniques are used to learn a plenty of non –linear schemes. It is applicable for handwriting recognition, information extraction, chemo informatics, 3D reconstruction, bioinformatics etc. There are many kernel methods are available like fisher kernel, graph kernel etc.

11. Trace transform

This technique is a generalization of the radon transform. In this technique we trace an image with straight lines besides which image functions are computed. It is a new tool for image processing which can be used for identifying objects under different transformations, for example scaling, translation and rotation [24, 25, 29]. It can also be used for tracing face image. We can find out different trace transforms from an image using different trace functional. Limitation of trace transform is that it cannot cope with occlusion. Also features constructed are not invariant to strong changes in illumination.

12. Active Appearance Model(AAM)

This technique is used for matching a stastical model of object shape and impression to a new image. It is a computer vision algorithm used widely for matching and tracking faces and for medical image interpretation. This technique is related to the active shape model (ASM).One disadvantage of ASM is that it does not take advantage of all the available information, only uses shape constraints. This can be modeled using an AAM [24, 25, 30]. It uses the difference between the current estimate of appearance and the target image to drive an optimization process. It exploits the advantage of least square techniques and used to match image quickly.

13. 3D Morphable model(3DMM)

Mostly human face is a surface lying in the 3D space. This is a technique used for representing faces, specifically to handle facial variations, such as pose, brightness etc. It encodes shape and texture in terms of model parameters. It recovers these parameters from a single image of a face [24, 31]. 3DMM can used to recover 3D face (shape and texture) and scene properties (pose and brightness) through a fitting process.

14. Bayesian Framework

This technique is used to find a probabilistic similarity based on Bayesian belief that the image intensity differences are characteristics of typical variations in appearance of an individual relationship between set of variables [24, 32]. These techniques are graphical models for defining two

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different classes of facial image variations defined as: first is an intrapersonal variation for example persons having different poses, expressions and side views and second one extra personal variation like twins or father-son relation. Bayesian rule is used to find similarity among faces.

15. Support vector Machine(SVM)

These techniques are used in machine learning which analyze data used for classification and regression analysis [24,25]. It is used to find the hyperplane that separates the largest possible fraction of points of the same class on the same side. Principal component analysis is used to extract features of face images and in next step SVM are used to learn discrimination function between each pair of images.

16. Hidden Markov Model(HMM)

This technique is a simplest dynamic Bayesian network. In this technique output dependent on the state is visible, but state is not directly visible. Every state has a probability distribution over the possible output tokens. HMM is a generalization of a mixture model where the hidden variables are related through a Markov process rather than independent of each other. These techniques are used in speech recognition, handwriting recognition, and gesture recognition [24, 25].

17. Video based face recognition algorithm

This technique has more advantages over the image-based recognition. It allows learning or updating the subject model to improve recognition results. It is a challenging technique which suffers from low quality facial images, brightness changes, pose variation, motion blur etc. Recognizing humans from real surveillance video is difficult; still a lot of improvement has been made [24,25,33].

These methodologies are being used by various authors for recognizing face having different facial expression, pose, illumination and orientation. Advantages, disadvantages and application of 10 methodologies are discussed in Table 1.

Table1: Comparative study of different methodologies for 2D and 3D face recognition

S.No.	Methodologies used	Advantages	Disadvantages	Application
1.	Eigen faces	Dimensionality reduction	Sensitive to lightening condition ,pose illumination	Recognizing face
2.	Neural network	Efficient	Applicable for small number of classes	Character recognition, pattern recognition, object recognition, face recognition
3.	Fisher face	Invariant to light intensity	Time consuming	Face recognition
4.	Elastic bunch graph matching	It will identify people even if some features are missing upto 22 degree of rotation	Sensitive to lightening condition	Face recognition
5.	Template matching	Easy to implement	Costly	Recognizing face
6.	Geometrical feature matching	Applicable for large set of database	Slower recognition rate	Face recognition
7.	PCA	Applicable for lower dimensional space	Sensitive to lightening	Recognizing face
8.	ICA	Similar to PCA that means used for dimensionality reduction	Sensitive to lightening	Applicable for FERET database for recognizing face
9.	LDA	Applicable for linear combination of features	Time consuming	Pattern recognition ,machine learning, face recognition
10.	Video based face recognition algorithm	advantageous as compared to image based recognition	Low quality facial image, brightness, pose	Real time application for recognizing faces

III. PROPOSED ALGORITHM

In this paper we proposed face recognition algorithm for 3D images for Facial identification as shown in figure 4 and Flow of Image are given below

Step I: We read a query image (input image)

Step II: Face identification is done from N number of face image stored in the database.

a) First we find out the brightness compensation in image
b) After brightness compensation we find out color space transformation
c) After transformation we detect skin color of the image.
d) After color detection variance based segmentation is done
e) In next step we find out the connected component and grouping of face image

Step III: Facial features are detected in following ways:

a) First we identify eye/mouth
b) After eye/mouth detection face boundary is detected
c) In next step verification is done or eye mouth triangle is found out.

Step IV: Face image match with enrolled users database and output image is displayed

In this algorithm we use the concept of Principal component analysis (PCA) and eigenfaces both for detecting 3D images.

Proposed face recognition algorithm for recognizing 3D images as follows:

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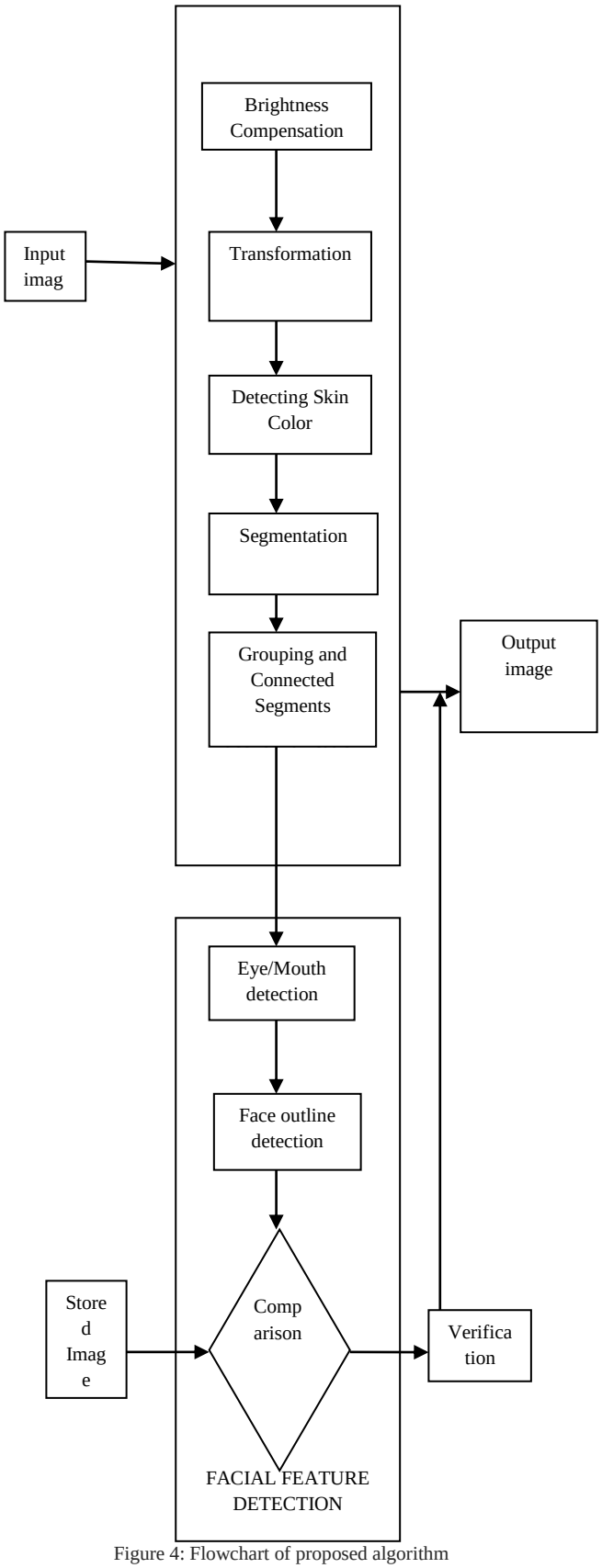

Figure 4: Flowchart of proposed algorithm

IV. CONCLUSION AND FUTURE WORK

Face recognition is one of the challenging tasks in the field of computer vision. In this paper we discussed various methodologies used for face recognition. We also discussed their advantages and disadvantages. In future we can use any of the methodology as per requirement and application. These algorithms can be applied to improve the efficiency and performance of the face recognition algorithm. Face recognition is not just an unresolved problem but also the source of new applications and challenges. We proposed an algorithm for face recognition for 3D images Applicable in a variety of domains like passport identification, ATM, health-card system**,** driving license system, surveillance operation like CCTV in public places.

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