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Evaluation of Composite Material Based Different Phases of Face Recognitions System

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Abstract

Composite materials can indeed play a crucial role in various phases of a face recognition system, offering advantages such as lightweight construction, durability, and tailored mechanical properties. Let's explore how composite materials can be utilized in different phases of a face recognition system. A composite material based different phases of Face recognitions System is software that recognizes or verifies a person based on a digital image or a frame from a video source. We investigated a facial recognition system using support vector machines (SVM), a type of machine learning, in this review. Advanced composites are widely favored across various engineering applications due to their exceptional specific strength and specific stiffness, offering superior performance relative to their weight. Within the aircraft and aerospace industries, high-strength fibers such as carbon, glass, and Kevlar are commonly employed. We compared various facial composite material based different phases of facial recognitions System using a global method of feature extraction based on Histogram-Oriented Gradient. Face detection is accomplished using Convolutional Neural Networks, a subset of Deep Learning (CNN). It is a multi-layered structure that has been taught to use categorization to perform a specific task. Our study provides a thorough introduction to face detection, as well as various approaches, computer vision fundamentals, and applications that will be useful in image processing and computer vision research.

Keywords: Composite material, face recognition, SVM, CNN, HOG, biometric authentication

INTRODUCTION

Composite materials can indeed play a crucial role in various phases of a face recognition system, offering advantages such as lightweight construction, durability, and tailored mechanical properties. Let's explore how composite materials can be utilized in different phases of a face recognition system. A significant area of computer vision research is face recognition. Face detection and identification in photographs is simple for people, but not for computers. The multidimensional structure of the human face necessitates the use of superior computational methods for recognition. Advanced composites are widely favored across various engineering applications due to their exceptional specific strength and specific stiffness, offering superior performance relative to their weight. Within the aircraft and aerospace industries, high-strength fibers such as carbon, glass, and Kevlar are commonly employed. These fibers contribute robust tensile strength essential for supporting both tensile and bending stiffness within composite structures. Polymer-based matrices play a crucial role in these composites by acting as a protective layer for the high-strength, brittle fibers, particularly against impacts. Moreover, the matrix material serves to absorb vibrational energy, enhancing the structural integrity of rigid components, particularly in safeguarding against seismic disturbances. The breadth of other features of the face, such as the

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lips, nose, and eyes, as well as the height of the faces, are all patterns that can be used to identify faces in photographs. There is a clear pattern: comparable faces have similar dimensions whereas distinct faces have varied dimensions. The mechanical characteristics of Natural Fiber Reinforced Polymer (NFRP) composites are primarily dictated by the interfacial bonding between the natural fibers and the surrounding matrix. Various micro-mechanical tests, such as the single fiber fragmentation test, single fiber pull-out test, micro-bond test, and single fiber compression test, are commonly employed to assess these interfacial bonding properties in fiber-reinforced composites. Researchers like Beckermann and Pickering [6] have investigated the bonding properties of hemp fibers, particularly when treated with a surface coupling agent known as maleic anhydride modified polypropylene (MAPP). This treatment enhances the bond between the fibers and the matrix. The fragmentation test, for instance, is conducted to determine the critical length (Lc) of the fiber.The several facial recognition algorithms we covered in the paper are CNN (Convolutional Neural Network), SVM (Support Vector Machines), and HOG (Histogram Oriented Gradient). Also, we will see a comparison of numerous technologies across various criteria so that we may decide which to choose. We observed comparisons between many techniques, including the haar cascade and the HOG, in some research studies. By the end of the essay, we will also have read a few studies where face recognition has been used in a variety of contexts, including tracking staff productivity and phoney GAN- generated face recognition. As this technology is becoming more and more common, many people are worried about their safety and privacy. So, as technology advances, it is crucial to control the power of this new world so that it is not abused. Nowadays, face recognition technology is widely used.

LITERATURE REVIEW

Biometric Authentication: A Review

The use of biometric authentication to provide personal identity has become more widespread. The practice of fingerprinting was originally documented in China in the 14th century. Procedures for signature biometric authentication were developed in the 1960s and 1970s. The following methods for biometric identification have been created: Speaker Recognition Technique, Signature Verification Technique, Hand Geometry Technique, IRIS Technology, Face Recognition Technique, and Fingerprint Technology.

Future cognitive biometrics systems will search at ports and high-security zones using the brain's reaction to olfactory cues, facial perception, and mental performance. Other biometric techniques, such as those based on gait (the way a person walks), the retina, hand veins, ear canal, face thermogram, DNA, odour and fragrance, and palm prints, are also being developed.[1]

The level of security is important when using biometric authentication.

- The percentage of unsuccessful matches between an input pattern and a database pattern that doesn't match is measured by the false acceptance rate (FAR) and false match rate (MAR).
- *False Reject Rate (FRR) or False Non-Match Rate (FNMR):* This statistic represents the proportion of legitimate inputs that the database falsely rejects. Relative Operating Characteristic (ROC): The ROC plot is created by indirectly modifying the variables while graphing the FAR and FRR values.
- *Equal Error Rate (EER*): The rate at which mistakes are equally accepted and rejected.
- *Failure to Capture Rate (FTC):* Generally speaking, FTC refers to the likelihood that the system will miss detecting a biometric characteristic even when it is presented correctly.
- *Inability to Capture Rate (FTC):* Generally speaking, FTC refers to the likelihood that the system will miss detecting a biometric characteristic even when it is presented correctly.

GAN-generated faces detection: a survey and new perspectives

The study provided a thorough analysis of GAN face detection techniques. They were divided into the following 4 primary groups by Paper:

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- *Deep learning-based approaches*: It performed admirably when it came to GAN-face detection. To analyse or explain the learnt model's decision-making process as a black box,however, it is challenging. However, in addition to overall accuracy, phoney face detection in the actual world favours explainability.[2] People are more interested in use cases like "This photo resembles someone I know, but should I believe the AI system when it says it's phoney or real?"
- *Physically based techniques*: These techniques are more resistant to adversarial assaults, and the anticipated outcomes allow for human users to make intuitive interpretations. [2]
- *Methods based on physiological principles*: They are easier to comprehend. Environmental restrictions like occlusion and the visibility of the eye from the facial picture remain a significant barrier, just like with other forensic methods. The use of end-to- end learning's potential to enhance model training is still up for debate.
- *Human visual performance*: Since GAN models are actively being developed, it is anticipated that it will become harder to distinguish GAN-faces in the future. It's critical to identify universal indications that people may use to recognise GAN-faces with accuracy [2].

A Review of Face Recognition Technology

A subset of the visual pattern recognition issue is face recognition. It consists of picture preprocessing, face identification, face position, identity identification, etc. [3]

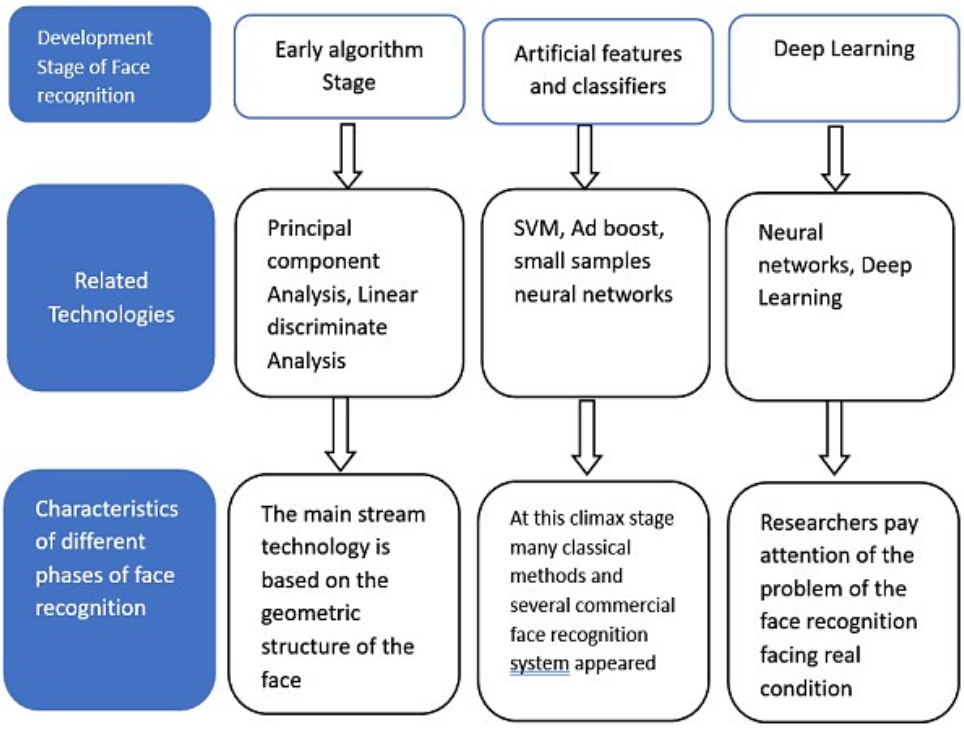

Figure 1. Different stages of face recognition

a. Early Algorithm Stage - Identifies geometry of the face.

(i) *Principal Component Analysis (PCA):* reduction of data dimensionality algorithm Prior to doing further studies, PCA is typically used to preprocess the data. When dealing with data that has more dimensions, it may eliminate extraneous data and noise, preserve the key aspects of the data, significantly decrease the dimensions, accelerate the processing of the data, and save a tonne of time and money. Therefore, dimensionality reduction and inter data visualization are the two main applications of this approach.

(ii) *Linear Discriminant Analysis (LDA)*- is employed for categorization. While LDA wants the variation within the same subcategory of groups of data after projections to be as minimal as

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feasible, PCA demands the data variance following image compression to be as great as feasible so that the data could be divided as broadly as possible. [12]

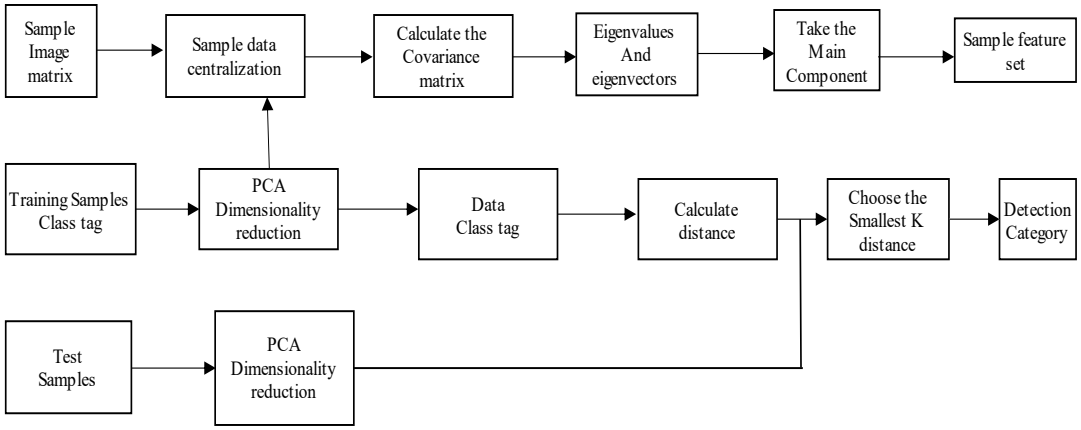

Figure 2. PCA is combined with KNN face recognition process

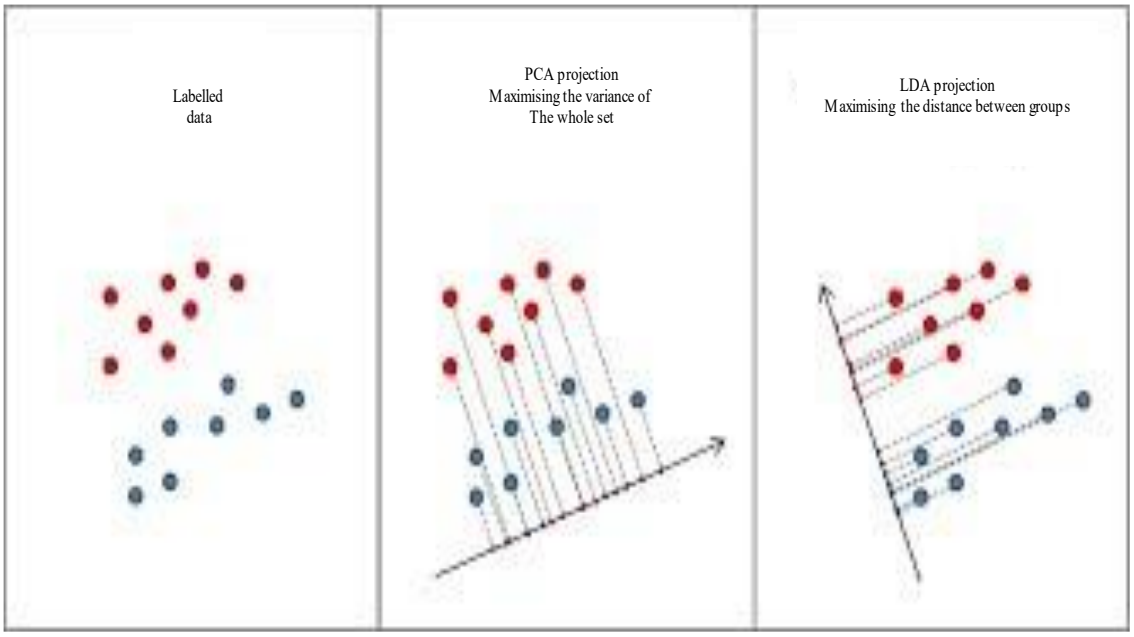

Figure 3. Comparison between PCA & LDA. a) PCA, b) LDA

b. Artificial features and classifier stage- Many classical methods and several commercial FR systems appeared.

(i) Support Vector Machine (SVM)- To discover the hyperplane for differentiating between distinct faces, we combine the acquired face data using SVM.

(ii) Adaboost - It is used to find faces. Any learning algorithm may be more accurate by using boosting methods. The basic goal is to combine many classifiers into a better final classifier using a few straightforward principles in order to improve overall performance.

(iii) The AdaBoost classifier combines many weak classifiers Gi into a classifier, and each classifier has a weight wi, as indicated in the following diagram.

$$\mathbf{G(x) = sign(\ Xn\ i=1\ wi * G(xi)}$$

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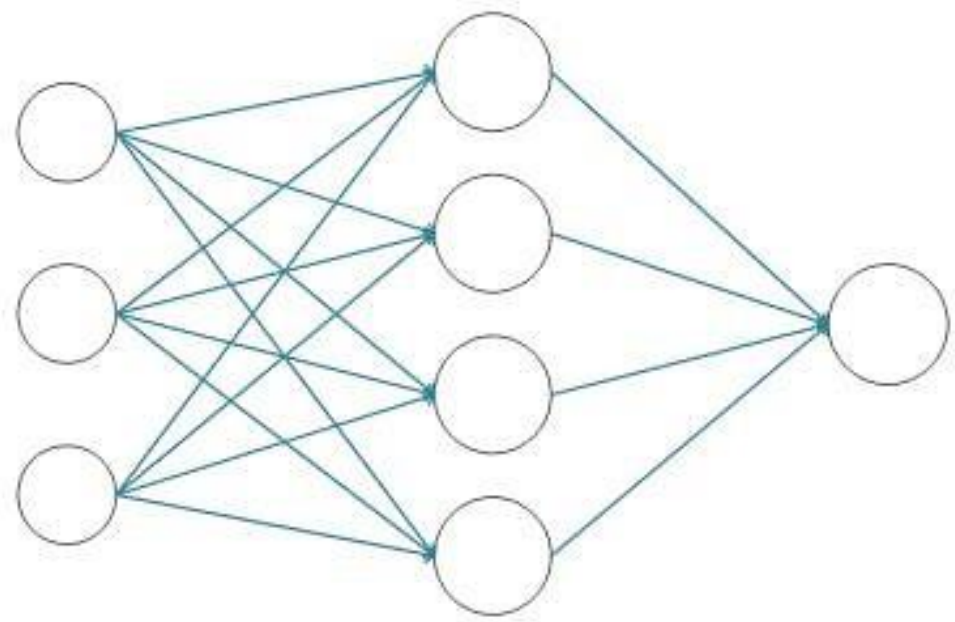

Figure 4. Neural network representation

c. Deep learning stage - studies focused on the FR challenge in practice.[4] A subset of machine learning is deep learning. Without the need for feature extraction steps, deep learning can automatically identify the features required for classification during the training process.[4][5]

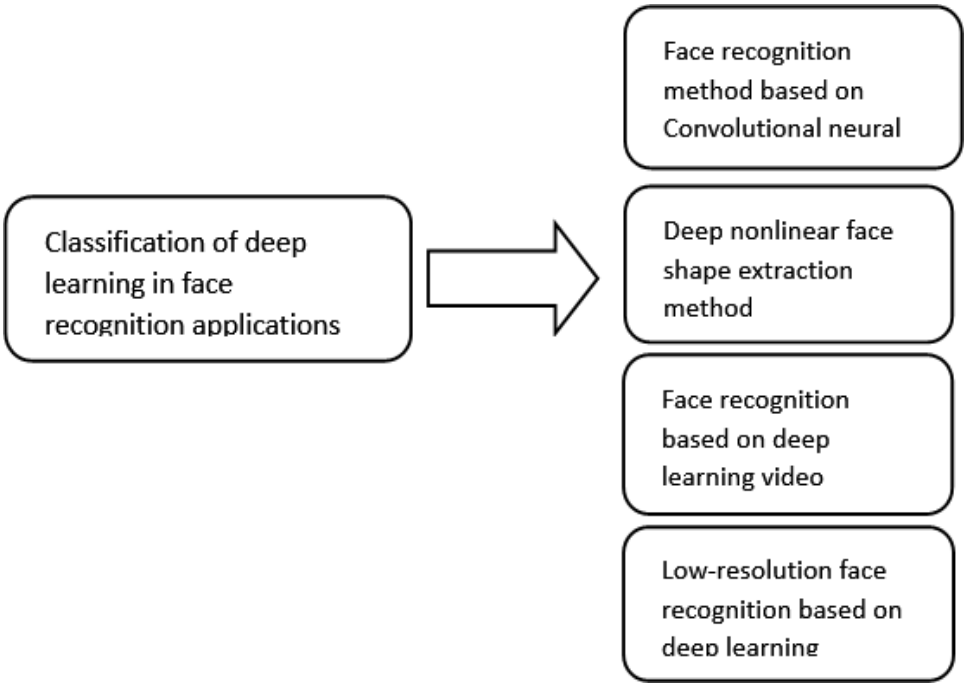

Figure 5. Classification of deep learning

FACE RECOGNITION USING MACHINE LEARNING

In this study, two normalisation processes are added to two of the layers, updating the Convolutional Neural Network (CNN) architecture. Soft - max classification was used to categorise faces within CNN's fully linked layer, and Architecture was utilised to extract distinctive facial characteristics.[13] There are several deep learning methods, such as Convolution Neural Network, Deep Belief

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Connection, and Stacked Autoencoder (CNN). CNN is a popular algorithm for face and image recognition. In order to enhance the amount of characteristics, CNNs, a type of artificial neural network, employ the convolutional approach to extract characteristics from input data. LeCun first suggested CNN, which was initially applied to the recognition of handwriting.[15][16]

Neurons with learning weights make up CNNs. Convolution, pooling, Rectified Linear Unit (ReLU), and Fully Connected layers make up CNN's structural layers. Using the MatConvNet software tool beta23 version, we created our CNN. The first and last convolution layers' outputs are batch normalised in the proposed approach, and the network is able to attain greater accuracy rates as a result. To categorise the faces in a fully linked layer step, the Softmax Classifier is utilised. [6]

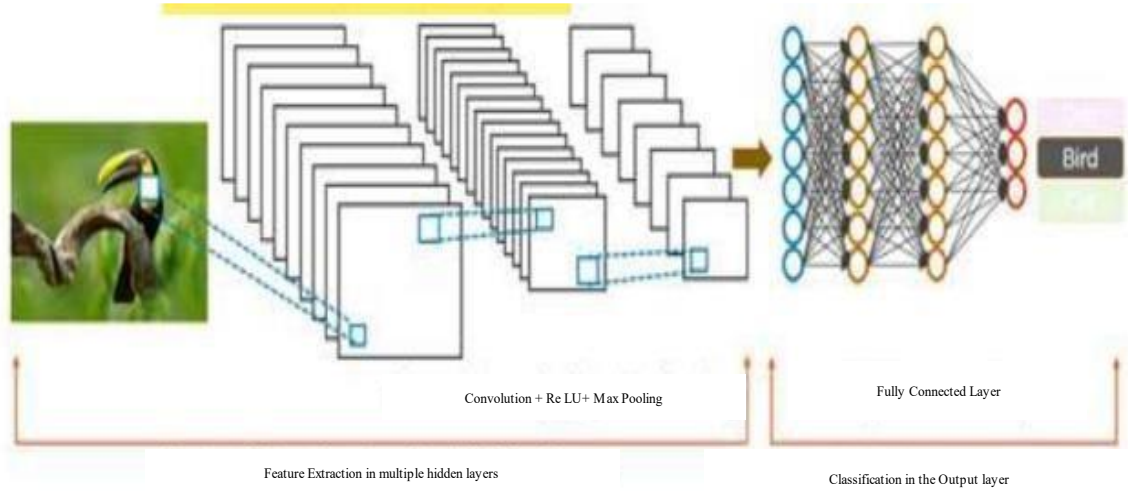

Figure 6. Layers of CNN

A Review: Facial Recognition Using Machine Learning

Based on CNN, this paper proposes a method for understanding facial expressions.[18][19] CNN (Convolutional Neural Network) can be used to recognise images. CNNs are multi - layer perceptrons that can automatically decipher semantic information from facial expressions without the requirement for manually created feature descriptors. CNN is composed of hidden layers that take inputs and convert them into outputs that are then forwarded to the following levels. The many layers included fully linked, convolution, and pooling layers. These convolutional layers use a weighted matrix depending on the pattern that has to be recognised to detect patterns. Furthermore, after classifying the input, these weights are updated based on the error and loss.[17]

A facial recognition algorithm is used to extract the face using video frames and construct a database. The collected facial photos are subsequently pre-processed. Then, utilising inputs of face photos, particular ML algorithms are trained. Classifiers are then employed to categorise. Some recent advances outline the methods used to assess the five basic emotions or moods commonly captured in human-faced images. Normalcy, happiness, tiredness, disgust, and astonishment by automatic devices are the major emotions. In classifying emotions, the emphasis is on ANN and SVM. In order to effectively identify and recognize faces on MATLAB, the face recognition technique is implemented in this article. Validation and identification are the two key activities involved in the face recognition process. Identification denotes a comparison between the query picture and the image template already present in the database. The database is referred to as a gallery, and the input picture or the test image is also known as a probe. Our capacity to recognise faces is unaffected by scale or backdrop, and we are able to do so even when just a little portion of the face is visible or after a period of time has elapsed. For face recognition, there are primarily three methods: [7]

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Face Detection and Recognition Using Machine Learning Algorithm

Face recognition is a continually growing and intriguing field with numerous applications. In this paper, HOG (Histogram of Oriented Gradient) based face detector technique is used and for preprocessing, CLAHE (Contrast Limited Adaptive Histogram Equalization) is used which undoubtedly produces more accurate results than other algorithms used for face detection. SVM (Support Vector Machines) are used for classification purposes. Preprocessing is done for removing the noise, contrast enhancement, and illumination equalization. Recognition faces are not as easy for machines as human faces consist of multidimensional structure. A particular face is converted in form of numbers as ML algorithms accepts numbers only. Nowadays, an approach named as Principal Component Analysis (PAC) is used for dimension reduction and subspace projection but gives less accurate results than HOG as HOG features have advantages of orientation binning, scale gradient, etc. Other studies have determined that HOG is more accurate than the Haar-Cascade Algorithm, which has a higher rate of false-positive picture identification. The HOG technique makes use of a revolving detection window that widely revolves around the image used in pedestrian detection.[8] So it is concluded that although HOG is a time-consuming algorithm it gives more accuracy and productivity than other machine learning algorithms.[20]

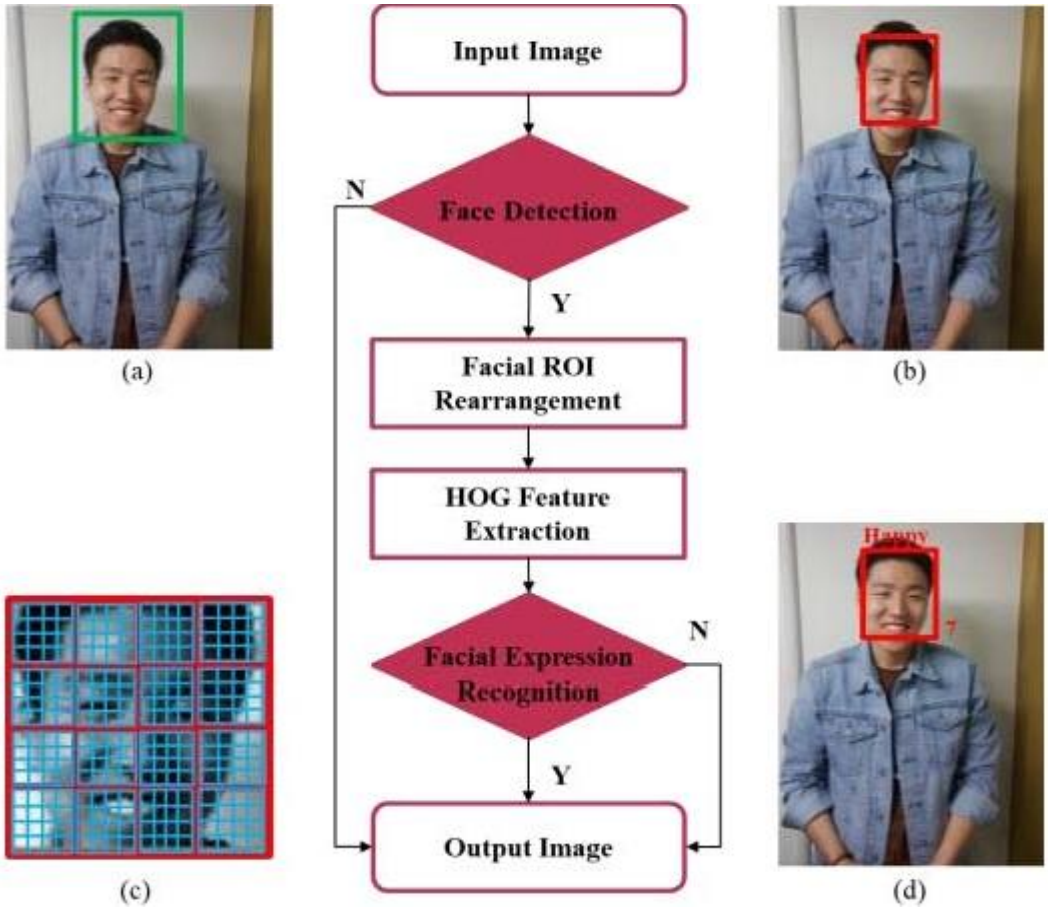

Figure 7. Proposed flow chart

Face Recognition using Machine Learning

In this research, we proposed a machine learning-based facial recognition system that uses support vector machines (SVM). The first stage that must be completed is face detection, which is done using the widely used Viola-Jones algorithm. The histogram of oriented gradients (HOG), which effectively retains the edges of the face as well as the directionality of those edges, is used to extract features from the face once it has been detected. Last but not least, the facial databases are trained and classified using a multi-class SVM, where each distinct face in the facial database represents a class.[9]

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A common training tool called Support Vector Machines (SVM) can be used to create a model based on different classes of data and then distinguish between them.

Face detection and recognition: a review

In order to effectively identify and recognise faces on MATLAB, the face recognition technique is implemented in this article. Validation and identification are the two key activities involved in the face recognition process. Identification denotes a comparison between the query picture and the image template already present in the database.[14] The database is referred to as a gallery, and the input picture or the test image is also known as a probe. Our capacity to recognise faces is unaffected by scale or backdrop, and we are able to do so even when just a little portion of the face is visible or after a period of time has elapsed. For face recognition, there are primarily three methods: [10]

a. *Feature based approach*: basic face features are considered as the input data.
b. *Holistic approach*: Entire face is taken as input.
c. *Hybrid approach:* Combination of feature based and holistic approach.

Facial recognition in photos and real-time face detection, which uses image invariants, are further categories of the face recognition process. A typical human face is used for the grey- scale intensity distribution in order to implement it. Face detection is divided into two strategies:

a. *Geometrical Features*: The benefit of utilising geometrical characteristics as the foundation for face recognition is that it is feasible to recognise faces even with noisy pictures and very low resolutions. The main drawback is that it is very difficult to automate the extraction of face geometrical elements.
b. *Template matching*: The whole face areas (pixel matrix) are extracted as the foundation of the pattern matching technique, and they are then compared with the saved photos of known individuals.

Table 1. Comparison of Technologies and phases included in Face detection and Face Recognition System

S.N.	Phases	Sub process	Reference	Detailed Remark
1.	Face Detection	• Viola Jones Algorithm	[9]	Selection of features, evaluation of features, feature learning to develop a classifier, and cascading classifiers are the steps.
		• GAN Face detection	[2]	Methods: Deep learning, Physical, Physiological, Human Visual
2.	Face Extraction	• HOG	[8], [9]	Steps include calculating the image's gradient, histogram of gradients, normalising histograms, and finally forming the HOG feature vector.
		• CNN	[6], [7]	The proposed algorithm is notable for using batch normalisation for the outputs of the first and final convolution layers, and the network achieves higher accuracy rates. In a fully connected layer step, SoftMax Classifier is used to classify the faces.
3.	Training Model	• SVM	[9]	To determine what best distinguishes the numerous feature vectors of one unique face from those of another unique face, create a model based on several classes of data.
4.	Classification	• AT&T Dataset	[9]	Consisting of forty distinct faces, each with 10 different pictures.
		• YALE-B Dataset	[9]	The subset we tested on had ten distinct faces and twenty photos apiece.

Measurement of the Acceptability of facial recognition - Enabled Work Surveillance Cameras in the Public and Private Sector

In this paper the author showed the study that using facial recognition surveillance systems is acceptable by the public and private sector employees of different countries and what their concerts are

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related to. Some accept the surveillance, some object completely and some have their opinions depending on the circumstances. The paper also depicted that facial recognition is increasing rapidly so that safety and employees performance can be measured but some employees take it in an offensive manner and name it under trust issues, privacy breach and also want to know exactly about when and how long they will be in surveillance. Due to which many systems and scenarios and explanations have been driven undertaking government guidelines into vies to justify the use of surveillance. The concussion to it is that one must accept the evolving technology with open heart and look into its positive points more clearly.[11]

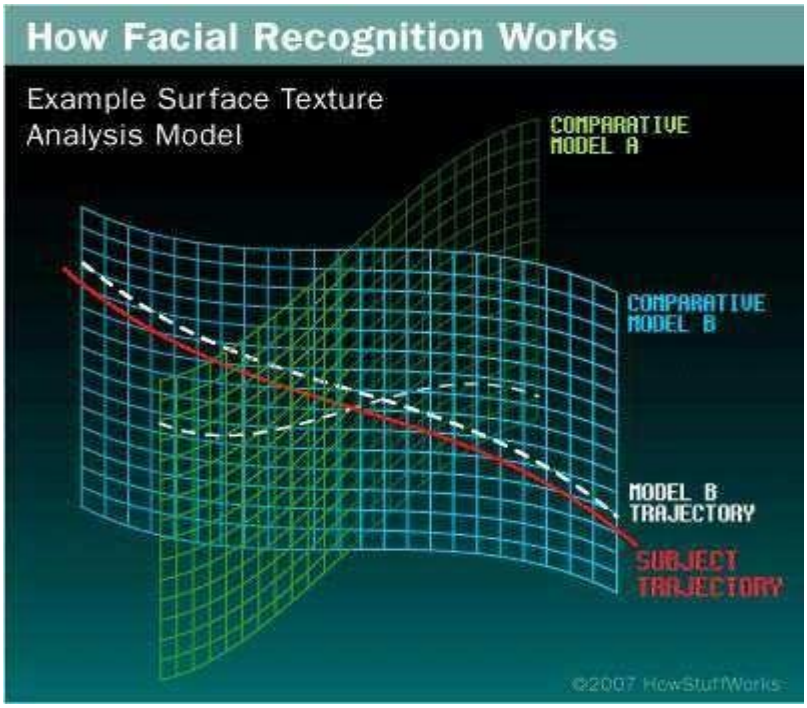

Figure 8. Working of facial recognition

A Review Paper on Facial Recognition

One of the numerous companies creating facial recognition technology is Identix, which has its headquarters in Minnesota.[22]

Its software, FaceIt, has the ability to recognise a face in a crowd, separate the face from the background, and compare it to a database of previously captured photographs. These landmarks are referred to as nodal points by FaceIt. An average human face contains 80 nodal points. The programme takes measurements of many features, including the length of the jaw, the breadth of the nose, the depth of the eyelids, and the distance between the eyes. A new solution from Identix helps with precision.[22] The creation of Face It Argus employs skin biometrics, the distinctiveness of skin texture, to produce findings that are even more precise. The method, dubbed Surface Texture Analysis, functions very similarly to facial recognition. A skin print is a photograph of a patch of skin. They have provided an overview of facial recognition technologies in this paper.[21]

CONCLUSION

The objective of this study is to evaluate the extreme machine learning algorithm's facial recognition performance both by itself and in conjunction with an ensemble learner. Face identification systems are always getting better thanks to the enormous assistance provided by machine-learning algorithms, which enable computers to decipher facial expressions and recognise emotions.[21] The CNN architectural style composite material based different phases of Face recognitions System is empirically evaluated in this study. Our focus has been on how various methods and concepts, such as support

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vector machines, neural networks, and convoluted neural networks, relate to deep learning (CNN). [23] Geometrical structures are linked to the biological features of the human facial that are related to diverse expressions including happiness, sorrow, fear, rage, surprise, and disgust that are restored as the recognition system's base matching template. The public and private sectors, as well as ATMs, duplicate voter detection, visa and passport verification, drivers licence verification, and other tests, can all benefit from the usage of this technology. The facial recognition methodology has one key benefit over all other biometric methods: it is user-friendly.

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