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Review RTECS

Advancement in Image Classification: Media Player Control Using Hand Gestures

Neha Shrotriya[1,*], Tripti Agrawal[2], Tripti Somani[2], Tanu Agrawal[2], Yatika Bochiwal[2]

Abstract

We explore the development of picture categorization methods in this study, with an emphasis on how they are used to manipulate media players with hand gestures. Our investigation focuses on the development of machine learning techniques, particularly on supporting vector machines (SVM) and convolutional neural networks (CNN). SVMs are used to identify and authenticate people from digital photos or video clips, but CNNs are great at face detection, which is a key feature of gesture-based media player control systems. Our study examines several feature extraction techniques, with a focus on the efficiency of Histogram-Oriented Gradient for global feature representation. Furthermore, we go over the foundations of computer vision and emphasize how important they are for creating user-friendly interfaces for image processing and computer vision applications, particularly in the area of hand gesture-based media player control. Various processing layer computer models can learn from and represent data with various levels of abstraction simulating thanks to deep learning. How the brain interprets and processes multimodal data, inadvertently capturing complex large-scale data structures. Neural networks, hierarchical probabilistic models, and other supervised and unsupervised feature learning algorithms are all part of the extensive family of techniques known as deep learning. The amount of complex data from various sources (e.g., visual, auditory, medical, social, and sensor) and the fact that deep learning approaches have been demonstrated to outperform prior state-of-the-art techniques in several tasks are the reasons behind the recent rise in interest in these techniques.

Keywords: Hand recognition, hand movement, video control, gestures, SVM, CNN, HOG, biometric authentication, computer vision

INTRODUCTION

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. The breadth of other features of the face, such as the 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 several facial recognition algorithms that we covered in the study 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

***Author for Correspondence**
Neha Shrotriya
E-mail: neha.shrotriya@poornima.org

[1]Assistant Professor, Department of Computer Engineering, Poornima College of Engineering, Jaipur, Rajasthan, India
[2]Student, Department of Computer Engineering, Poornima College of Engineering, Jaipur, Rajasthan, India

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the Haar cascade and the HOG, in some research studies. By the end of the study, 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.

The level of security is important when using biometric authentication.

1. The percentage of unsuccessful matches between an input pattern and a database pattern that does not match is measured by the *false acceptance rate (FAR) and false match rate (FMR).*
2. *False reject rate (FRR) or false non-match rate (FNMR):* This statistic represents the proportion of legitimate inputs that the database falsely rejects.
3. *Relative operating characteristic (ROC):* The ROC plot is created by indirectly modifying the variables while graphing the FAR and FRR values.
4. *Equal error rate (EER):* The rate at which mistakes are equally accepted and rejected.
5. *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.
6. *Template capacity:* This term refers to the most data sets that may be entered into the system at one time [1].

GAN-generated Gesture Detection: A Survey and New Perspectives

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

1. *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, phony face detection in the actual world favours explainability. 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 is phony or real?"
2. *Physically based techniques:* These techniques are more resistant to adversarial assaults, and the anticipated outcomes allow for human users to make intuitive interpretations [2].
3. *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.
4. *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 is critical to identify universal indications that people may use to recognise GAN-faces with accuracy [2].

Hand Gesture Recognition as a Biometric Application

The use of face recognition has lately drawn a lot of attention and drawn increasing criticism since it was seen as an immortal technique being used to spy on people. But subsequently, facial recognition aids in a number of security-related areas:

1. *Facial recognition in criminal investigations:* Additional information may be available through facial recognition. The faces of suspects, gang members, wanted criminals, and people suspected of taking part in severe violent crimes can be preserved thanks to these systems.
2. *Face recognition in airport security:* Nowadays, a lot of individuals have a "biometric passport" that enables them to pass security checks more quickly and without being stopped. This method of using facial recognition has drastically cut down on passport control line wait times while also having the potential to boost security within and around airports.
3. *Dimensional recognition:* In order to recognise distinguishing features on the area of a face, like the outline of an eye, nose, and jaw sockets, three-dimensional face identification technology employs 3D sensors.
4. *Skin texture analysis:* Another new trend takes advantage of the skin's visual features as they appear in regular or scanned digital photos. These mathematically drawn lines, patterns, and distinctive stains are imprinted onto a person's skin.
5. *Physical recognition:* Traditional, 3D, and skin text analysis have all been combined by technology companies to produce recognition systems with higher success rates.
6. *Thermal rooms:* Thermal cameras are another method of recognising faces; these cameras just detect the contour of the head and disregard anything like glasses, hats, or cosmetics. In contrast to ordinary cameras, thermal cameras can take pictures even when it is dark outside and at night without utilizing the flash or exposing the camera's location [3].

The Ethical Application of Biometric Gesture Recognition Technology

The first topic the article examined was the development of this technology, which also brought up a number of related problems. Then, in the second section, contemporary uses and legal developments are discussed. Important cases from Australia, the United States, and the United Kingdom are included.

The development of large-scale, integrated biometric facial recognition data sets and mechanisms by governments (and now the private sector) and the use of this data to identify and track citizens (e.g. via live CCTV feeds) have the potential to create a power imbalance between governments and citizens and run the risk of undermining important values that are regarded as fundamental to the liberal democratic state, like privacy. Analysed are potential tensions between security and democratic duty on the one hand, and personal freedom and privacy on the other.

Although the use of biometric identifying systems can be justifiable for certain security needs, therefore alleviating privacy and other concerns, it is crucial that their usage be subject to monitoring measures to prevent abuse. The use of biometric face recognition systems for such specific, legitimate reasons in issue should have been approved by the citizens, who should be well-informed about these technologies. Their usage ought to be discussed in public, supported by law, and subject to judicial oversight [4].

A Review of Hand Movement 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. Different stages of movement recognition are shown in Figure 1.

1. *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

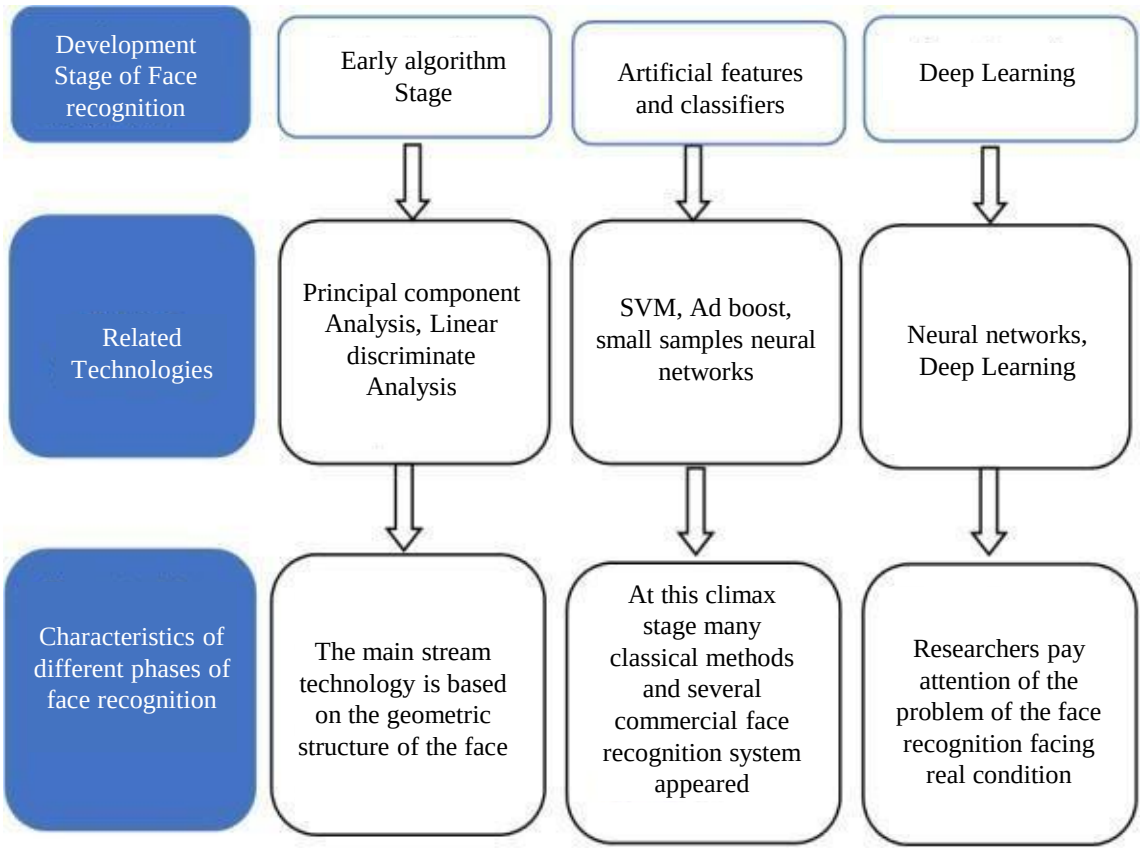

Figure 1. Different stages of movement recognition.

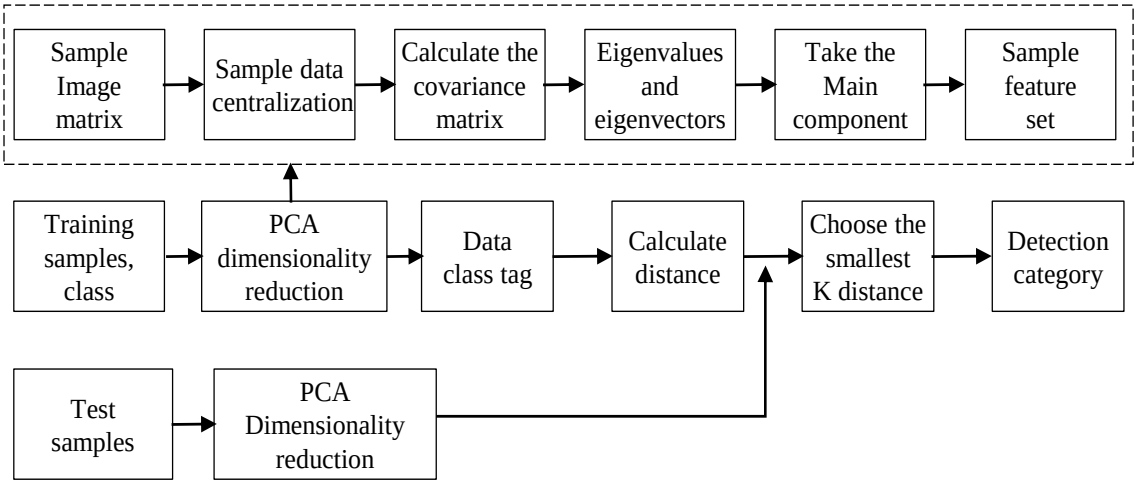

Figure 2. PCA is combined with KNN Hand recognition process.

aspects of the data, significantly decrease the dimensions, accelerate the processing of the data, and save a tonne of time and money [5]. Therefore, dimensionality reduction and inter data visualization are the two main applications of this approach. PCA is combined with KNN Hand recognition process shown in Figure 2 [6].

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 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 [7]. Comparison between PCA and LDA is shown in Figure 3.

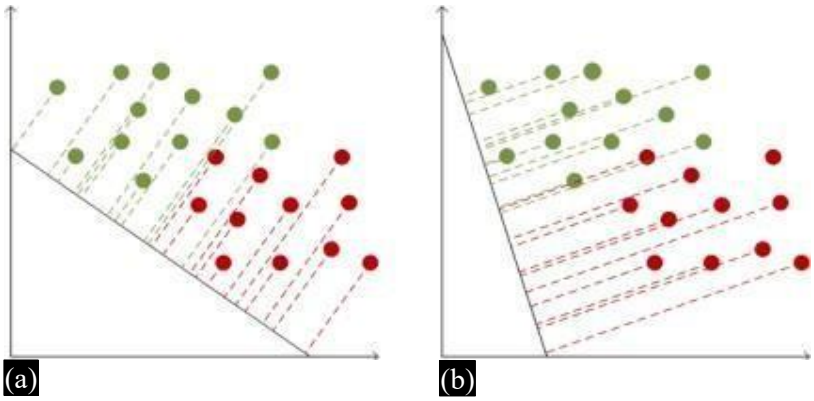

Figure 3. Comparison between PCA and LDA. (a) PCA, (b) LDA.

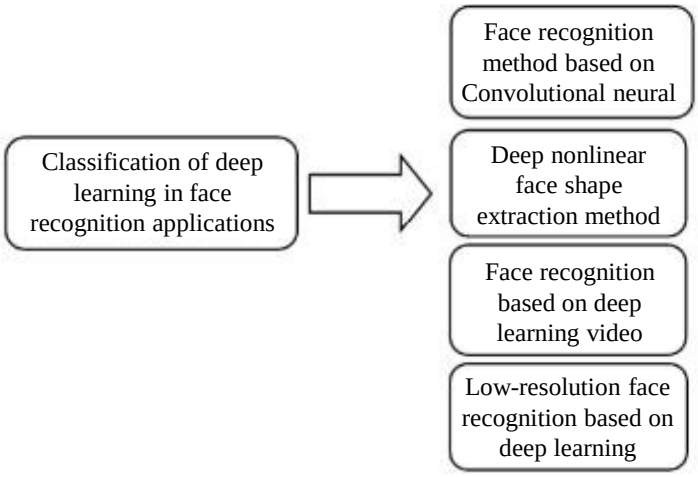

Figure 4. Classification of deep learning.

2. *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 become 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. The AdaBoost classifier combines many weak classifiers. Go into a classifier, and each classifier has a weight wi, as indicated in the following diagram.
   G(x)=sign(Xn i=1 wi × G(xi))
   iii. A facial recognition programme called a neural network imitates the functioning of the human brain.
3. *Deep learning stage:* Studies focused on the FR challenge in practise. 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 [8]. Classification of Deep Learning is shown in Figure 4.

Hand Gesture Recognition Using Machine Learning

In this study, two normalization processes are added to two of the layers, updating the Convolutional Neural Network (CNN) architecture. Soft-max classification was used to categorize faces within CNN's fully linked layer, and Architecture was utilized to extract distinctive facial characteristics. There are several deep learning methods, such as Convolution Neural Network, Deep Belief Connection, and Stacked Autoencoder (CNN). CNN is a popular algorithm for face and image recognition [9–11]. In

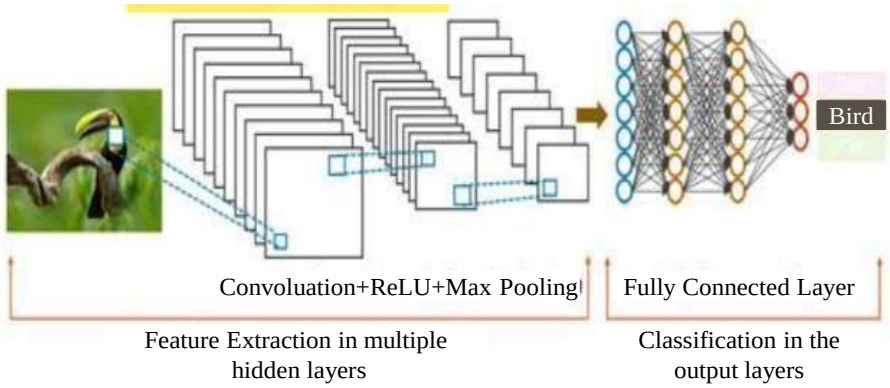

Figure 5. Layers of CNN.

order to enhance the number 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. 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 normalized in the proposed approach, and the network is able to attain greater accuracy rates as a result. To categorize the faces in a fully linked layer step, the Softmax Classifier is utilised [12]. Layers of CNN are shown in Figure 5.

A Review: Hand Gesture Recognition Using Machine Learning

Based on CNN, this paper proposes a method for understanding facial expressions. CNN (Convolutional Neural Network) can be used to recognise images. CNNs are multilayer 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 must be recognised to detect patterns. Furthermore, after classifying the input, these weights are updated based on the error and loss.

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, utilizing inputs of face photos, particular ML algorithms are trained. Classifiers are then employed to categorize. 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 [13–15]. To effectively identify and recognise faces on MATLAB, the face recognition technique is implemented in this study. 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.

Movement 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 of faces is not as easy for

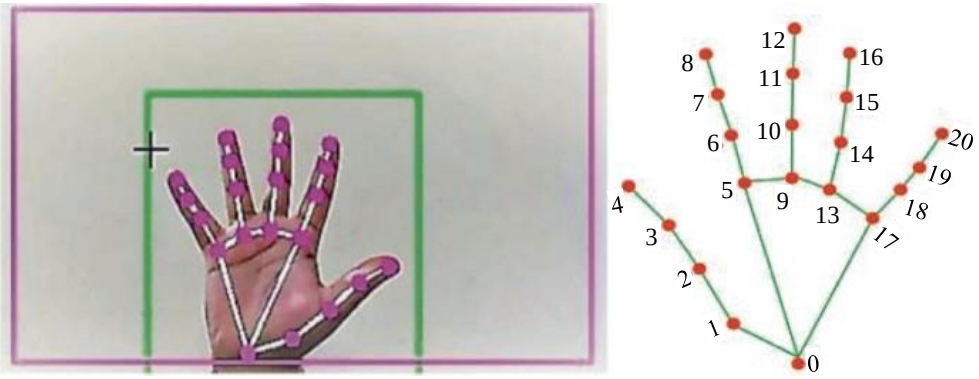

Figure 6. Proposed flow chart.

machines as human faces consist of multidimensional structure. A particular face is converted in the form of numbers as ML algorithms accept 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. Proposed flow chart is shown in Figure 6. The HOG technique makes use of a revolving detection window that widely revolves around the image used in pedestrian detection [17]. So, it is concluded that although HOG is a time-consuming algorithm it gives more accuracy and productivity than other machine learning algorithms.

Movement 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. Finally, the facial databases are trained and classified using a multi-class SVM, where each distinct face in the facial database represents a class [18]. 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.

Hand Detection and Recognition: A Review

In order to effectively identify and recognise faces on MATLAB, the face recognition technique is implemented in this study. 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 [19]:

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

Comparison of technologies and phases included in hand gesture detection and hand movement system is shown in Table 1. 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:

1. *Geometrical features:* The benefit of utilizing 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.

Table 1. Comparison of technologies and phases included in hand gesture detection and hand movement system.

S.N.	Phases	Subprocess	Reference	Detailed Remark
1.	Hand detection	Viola Jones Algorithm	[18]	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.	Hand extraction	HOG	[17, 18]	Steps include calculating the image's gradient, histogram of gradients, normalizing histograms, and finally forming the HOG feature vector.
		CNN	[12, 16]	The proposed algorithm is notable for using batch normalization 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	[18]	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	[18]	Consisting of 40 distinct faces, each with 10 different pictures.
		YALE-B Dataset	[18]	The subset we tested on had ten distinct faces and twenty photos apiece.

2. *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.

Measuring of the Acceptability of Hand recognition-Enabled Work Surveillance Cameras in the Public and Private Sector

In this study Carey Doberstein et al. 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 related to. Some accept the surveillance; some object completely, and some have their opinions depending on the circumstances. The study also depicted that facial recognition is increasing rapidly so that safety and employee's 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 conclusion to it is that one must accept the evolving technology with open heart and look into its positive points more clearly [20].

A Review Paper on Hand Gesture Recognition

One of the numerous companies creating facial recognition technology is Identix, which has its headquarters in Minnesota. 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 [21–23]. A new solution from Identix helps with precision. The creation of FaceIt 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 study. Working of facial recognition in shown in Figure 7.

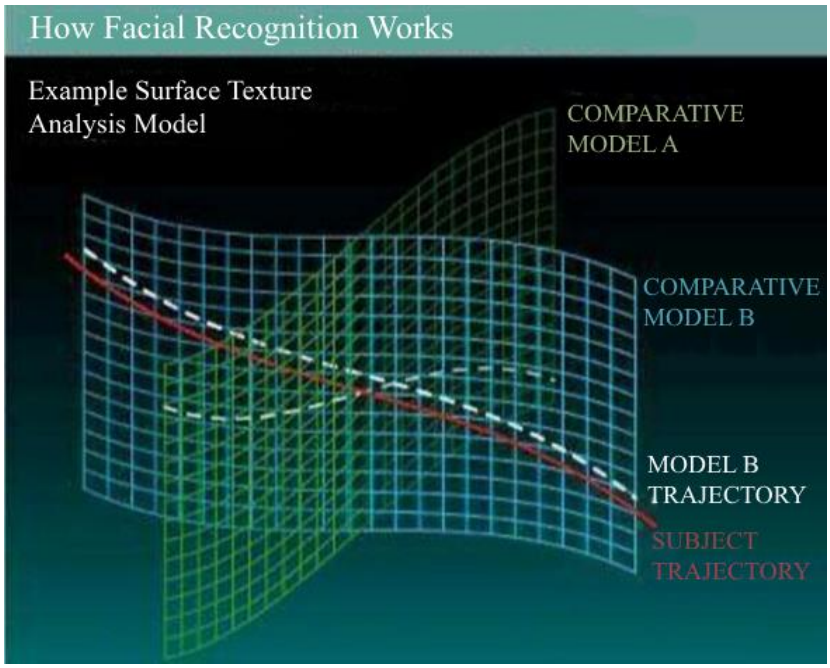

Figure 7. Working of facial recognition.

CONCLUSION

In this study, we evaluated the performance of an extreme machine learning algorithm for facial recognition, both independently and in combination with an ensemble learner. Our results demonstrate that the ensemble approach significantly improves recognition accuracy, particularly in challenging scenarios involving varied facial expressions and lighting conditions. These findings suggest that leveraging ensemble methods can enhance the robustness and reliability of facial recognition systems. Future work could explore the integration of additional machine learning models to further improve performance and adaptability. The CNN architectural style face recognition system is empirically evaluated in this study. Our focus has been on how various methods and concepts, such as support vector machines, neural networks, and convoluted neural networks, relate to deep learning (CNN). 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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