A Comprehensive Review of Face Detection Using Machine Learning and Deep Learning Approaches

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***Abstract*— Today, biometric systems are used in analyzing and verifying the unique physical or behavioral attributes of a person for authentication purposes or to be recognized. This is done to ensure that the person in question is indeed who he or she claims to be. Face recognition-based systems are the highest popular choice since they independent on user help every now and then; this had become more automated besides being easy for them to be operated. Many authentication systems up to now have used Iris, fingerprints and facial features. These systems have been utilized in the process of identification and verifications. One the other hand, people prefer face recognition-based system among these systems. This review paper conducts comparison and contrast of various face recognition methods along with hybrid combinations. The hybrid combinations are also compared in the review paper. Furthermore, the most frequently used datasets in this field are analyzed and reviewed. Apart from that, this paper argues the different facial recognition algorithms inspired by DL and also touched on what opportunities exist in this field in future along with some obstacles expected to be present.**

***Index Terms*— Face recognition, Machine Learning, Deep Learning, Convolutional neural networks, Principal component analysis.**

I. INTRODUCTION

A face-detection system is an efficient computer program that can identify individuals from a given image or video on the internet. There are many ways to achieve the stated goals. They have different ways of picking out many kinds of face traits and classifiers. Today, recognizing and finding faces is a big problem in Pattern Analysis, Computer Vision, Neural Networks and Machine Learning. [1] This problem is discussed in various study groups such as control areas and uncontrolled spaces. Face apps use 2D face photos and get different facial parts to test out various ways of learning. Recently, deep learning has given researchers in artificial intelligence a new way to find and identify faces. It is finding out what's important and it's a popular way to find faces in less time. It has expanded to tackle the tough problem of machine learning. It has assisted with human and computer problems [2].

Understanding faces with computer systems is a hard job in the area of seeing machines. Many systems and ways have been developed for identifying people. These big changes happened in the past 20 years. So, the face recognition systems can do a good job in normal situations now. But they have some issues in areas with light changes, different expressions and body positions. When face recognition systems work better, the difference seen in pictures becomes more noticeable [3].

Face authentication means letting in the right person; this is called a face identification problem. This method has two steps: Start by locating a person's face in a picture or video and then put its box around it. Throw away the extra parts of picture beyond this box.

Next, face recognition (FR): this means that the person's face found in the first step needs to be compared against those stored within a database. If there is a match made then permission from system will follow; otherwise, action must be considered by owner of it all. There are many things that change the FR method. These include physical elements (like light and blocking) as well face parts (such twin, family members share features, angle of face or changes from getting older). To get the best results for FR, we also need knowledge of psychology. This is so we can learn more about what face features are like [4]. Significant progress has been made in the field of face recognition (FR) through the utilization of established algorithms such as Principal Component Analysis (PCA) and Local Binary Pattern (LBP). In addition, Convolutional Neural Networks (CNNs), which are advanced deep learning techniques, have begun to be employed.

Deep learning is a high-level idea and method used to find faces for checking who they are. In deep learning, the computer acts as a learner and directly does sorting for next videos and images [5]. It is fixing the best-in-class issues and makes humans more precise and trustworthy. Deep learning uses labeled data to learn in network architecture. That has a lot of layers in its convolution neural network. The hidden layer has acted like a

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connection between the input and output layers. They are working on both simple and complex shapes of pictures. It fixes the finding and checking issues using as many layers in hidden areas that we can. The first introduction of deep learning and theory was produced in the 1980s [4].

The organization of the review paper is as follows. Section 2, explains the literature review and provides the main steps involved in the process of FR. In Section 3, summarizes the various FR algorithms based on ML and DL. Section 4, provided open challenges and directions for future scope, and Section 5, in concluding the work.

II. RELATED WORK

In this part, a quick review of the main ways people is identified mainly using side faces is provided and it talks about all the good points and bad parts for every method. For straightening faces, people usually first find two eyes and then make the face regular in shape. This is done most often. The other popular way of aligning faces relies on finding a certain number.

Many scientists have created different methods to spot and identify faces. When the first semi-automated algorithm was set up, this started in early 1960s. The main problem was making someone find facial features, measure the gaps and then do calculations. In the late 1980s, a major breakthrough was made when main factor analysis (PCA) was used in face recognition. I will talk about some papers on this subject below. For instance, some recent studies have focused on different ways to do rotation-invariant face recognition. In one example [6], a new method of grouping things using tools and math called Machine Learning is suggested in this paper. A new Deep Learning (DL) method using a deep Convolutional Neural Network (DCNN) model is created.

This works better than deciding someone's race based on their looks! But we need to use special fast computing devices (HPCs) for making a DCNN-based face recognition system. This is because the normal brain parts or CPUs don't process information quickly enough right now. Other papers [7] have been put forward by including this technology. They are famous in today's uses like phone unlock methods, identification systems for criminals and safety at home. Because it uses a photo of your face instead of things like cards or keys, this way is seen as safer.

This article looks at how to create a face recognition system using Python's OpenCV library and deep learning methods. In [8] they gave a summary of deep learning techniques used for recognizing faces. Talked about different parts needed to create a face recognition system that works on its own and how deep learning helps each part. We then talk about some problems with DCNNs for face recognition issues. Other books [9] make the program combine features by applying two trained InceptionNet-v1 and VggNet-16 models as deep feature extractors.

First, a Multi-Task Convolutional Neural Networks (MTCNN) face detector is used to find and align faces. After that each individual pre-trained CNN get the deep features from one person's picture in order to classify it or identify who this person might be. Second, parts gained from InceptionNet-v1 and VggNet-16 models are put together using the method that joins features one after another. In 2018, the way they suggested was checked with R-CNN and other methods. This showed better results even without putting face markers on pictures. You can make things better by using good ways to pick samples and boost data [21][19].

This will help improve any faster RCNN setup that gives great results on Face Detection Dataset and Benchmark (FDDB). The system suggested [11] is safer because you don't need any help like a key or card. You only require your face in this case. Usually, a system that recognizes humans has two parts. They are finding faces and determining who they belong to. This piece of writing talks about making a system to recognize faces using deep learning in Python with OpenCV.

The development of face recognition techniques has consistently progressed in tandem with advancements in machine learning, deep learning, neural networks, and other related technologies. Machine learning algorithms efficiently identify, capture, gather, analyze, and retrieve various facial characteristics and subtleties in order to match them with existing images and establish a correlation. Machine learning is an expanding discipline that has found applications in various domains, such as facial recognition [18].

Facial recognition technology is everywhere these days, even if people are not that aware of it. Many people use facial recognition technology to log onto their smartphones effortlessly. With advanced face detection software, surveillance operators can pick criminal faces out of crowds [12].

A. Comparison of Related Work

Comparison with related works shows how dynamic the face detection field research is. Group 1 are centered on deep learning applications, especially face recognition while group 2 advances improve Faster RCNN algorithms for face detection. Group 3 points to problems and summarizes current solutions, putting the complex mechanisms of facial recognition technologies in perspective. Members of Group2 conducted a critical analysis that distinguishes between machine learning and deep learning approaches, which offers meaningful advice. All in all, these comparisons reveal the dynamics of approaches showing that it is vital to conduct solid assessment faced with complex challenges on developing facial recognition systems.

To conclude, the trend to combine various deep learning (DL) techniques used in facial recognition systems, as demonstrated by Group 1 may be determined a leading theme within the chosen works. Significantly, research works including [2], [4], and [20] highlight the use of DL in face recognition adding finer insights into its complexities. Practical analysis of DL involvement in the process of facial recognition is shown Beyond DL, studies into improved Faster RCNN for face detection as can be observed in Group 2 ([6] and [17]) focus on improving current algorithms with the possibility of major breakthroughs in effectiveness and efficiency. Nevertheless, an

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in-depth comparison between ML practices and DL strategies (as investigated in [18], Group 2), uncovers subtle advantages / disadvantages to aid decision making on the choice of algorithm.

Under a more general heading, references discussing the identification of problems and critiquing current systems (Group 3) tend to provide helpful tips into facial recognition's many-faceted environment. Innovative opportunities include Presentation Attack Detection (PAD) methods [1] and multidimensional face recognition for changed faces [10].

Although the compilation of knowledge is fruitful, it should be noted that certain studies fail to provide specific accuracy metrics for their methodology and indicate that future researches need quantitative measurement tools in order to outline how effective suggested approaches are. These contributions together guide the discourse towards a more polished, finely tuned and secure domain of facial recognition technologies as it evolves.

III. MACHINE LEARNING AND ISSUES INVOLVED IN FACE RECOGNITION

The advancement of technologies such as machine learning, deep learning, and artificial intelligence has significantly enhanced the capabilities of face recognition systems. Machine learning tools efficiently identify and retain various facial characteristics, as exemplified.

These are then compared with old photos to make a connection between them. Machine learning is a fast-growing area and has been used for different jobs, such as recognizing faces.

Nowadays, facial recognition technology is all around us but many people might not know about it. Lots of people use facial recognition to easily unlock their smartphones. With better face finding tools, people watching can see criminal faces in big groups [12].

A simple way to say it, the process of using machine learning for facial recognition can get a little technical. It's more than what we can cover in this easy article about face detection with machine learning [13]. In this piece, we will look at some big issues that must be fixed by machines to accurately and fully identify a face.

A. face Detection

Finding faces is an essential part of recognizing and checking them out. This also includes a lot of other uses like recognizing facial expressions, tracking people's faces for security reasons and tags on social media sites. It even affects how cameras in phones can focus better. [2] This check will look at ways to find faces for recognizing and confirming them. In the past, one of the biggest challenges for facial recognition systems was being able to get high accuracy insituations they couldn't control. So, their use in real-life situations was not so good as shown in Figure. 1.

Figure 1. Example of face detection [2]

B.

Multiple approaches have to be tested to improve the accuracy and degree of precision of the face recognition.

We need to try many methods in order to make face recognition more accurate and detailed.So, if a system wants to see a face and know it's there, it has to find the face first. Table 1 shows a table that shows the differences. Datta and his team say that face detection comes in two types: one based on features, the other by pictures. In this review, we will only talk about a way to find faces using machine learning methods based on features [15].

Table 1. Compare face detection and face recognition [16].

Face Recognition	**Face Detection**
A technology capable of identifying a person based on certain aspects of their physiology.	A technology used to identify and locate human faces in digital images and video.
Face Recognition consists of face identification and face verification.	Face detection is a subset of face recognition.
Face recognition to be able to recognize a face.	The initial step to face recognition.
Check the database whether face identity is present.	Detects face and crop image to be preprocessed.
The system can isolate a human face from the other.	The image is automatically proposed to identify what is and is not a human face.

C. Pre-processing

It's a necessary and good step used before any picture process to get correct, trustworthy results. In picture processing, pre-processing is a step done before more work. The aim of this step is to either make image details better or improve picture quality by getting rid of unwanted distortions.

The careful work done before more advanced image processing steps like separating parts, finding features and selecting the best ones is very important for how well those coming after will perform. Before using clinical pictures, they often need to be re-done. This is because there are things like different levels of quality and poor contrast that can't always see correctly. When there are issues in pictures and they affect analysis, pre-

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treatment can help reduce them. [11] Before, various ways are used in pre-processing. These involve humans fixing errors and doing math along with adding more things or getting rid of noise.

D. Face Identification and Verification

The face recognition output system consists of two approaches: identification and verification (authentication). In simple words, face identification is about finding out who a person is from their picture or scan of their face in real life. It can be done with official certified photos taken by someone else even selfies [23]. It uses a collection of faces to compare the given facial information and find out who the person is. Software for face identification gives a clear way to find out who someone is by recognizing their face from big records in the database. It's good when we don't know who it is beforehand [17]. On the other hand, face verification works on the assumption that we already know who a person claims they are. When they present their face live, or submit a photograph of it to be assessed, this data is compared on a 1:1 ratio with a picture of their face kept in a database or checked together with another confirmed image make sure they match. The main goal of finding and confirming uses solving methods or cross-solving ways on blurry face pictures to make the system for recognizing faces work better [18].

E. Feature Extraction

This is another very important step that gets all the key traits and features from a face. These will then help in matching your face with others saved in database later on. Usually, feature extraction happens right after looking for faces. It's a very important step in systems that recognize people by their looks because how well it works depends on getting good details from the features we find. This is because the points on a face and those picked out by certain groups of neurons
decide how well features are shown. Old-style point finders rely on models, while many new methods use a series of steps based on regression.

Recently, significant advancements have been achieved through the implementation of deep dual pathway techniques and other solutions based on confidence maps. Common fiducial point methodologies include Active Shape Model (ASM), which has limited accuracy, partially improved by the advancements in Active Appearance Model (AAM) and Constrained Local Models (CLM). Cascaded regression models generally outperform CLMs due to the latter's inherent inability to accurately model the variations of local feature appearances. It is important to acknowledge, however, that there have been significant advancements in the development of highly efficient techniques utilizing CLMs. Generally, a structure for a high-level digital image processing system is shown in Figure 2. There are some main processing stages for classifying.

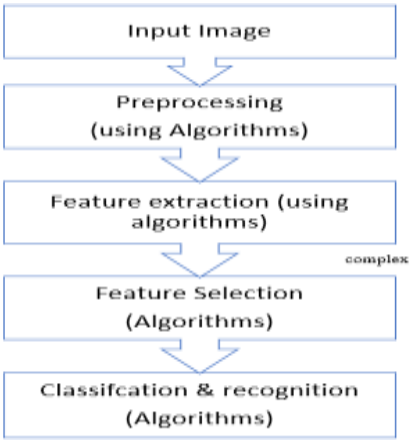

Figure 2. Data flow diagram face recognition is grounded upon in general.

IV. Architectures of Deep Learning for Face Detection.

It may seem that face recognition is very simple, while not only does it touch upon various issues of a complex format. However, to understand modern face detection better one would have to consider the way deep neural networks function. Thus, the aim here is to teach the neural network how to identify certain features of faces and calculate values that correspond with these. In turn, such numbers serve as people's identifiers. When several images of one person are launched into this network, the output will almost be identical. In contrast, if distinct photos of different individuals are used here the result will be drastically different.

In the field of machine learning we are familiar with solutions that involve choosing an algorithm, plugging in data and out comes some results. One thing that makes face recognition so special is the fact it does not require us to create our own neural network. In our case, we are fortunate to have a pre-trained model that accurately meets all of our needs. When presented with images of people's faces, this model produces a set of numerical codes face encodings. Faces represented by these encodings of different photographs can then be matched against each other to see if any given person's visage resembles the one in our collection.

Although the technique and processes responsible for face recognition are not known to many, they contribute significantly towards its success. Let us delve into what steps are involved in face recognition and how these play their part

A. Present the main ideas of deep learning CNN

The first thing is to gather and preprocess a dataset that will be used for training the face recognition model. Often researcher collects millions of images with face from various people. These images are then carefully labelled and annotated in order to identify the individuals. This dataset can be used as the training set for the model. This is followed by the training phase where deep learning techniques are applied. This phase often uses convolutional neural networks (CNNs) as the architecture.

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CNNs have multiple layers that extract relevant features from the input images.

B. Investigate major deep-learning architectures

The face recognition task's successful performance is proven for architectures such as VGG, ResNet and Inception. Every layer within the CNN carries a certain function, convolution, pooling or activation functions and so on of course refining features that had previously been extracted. The deep-learning algorithms use backpropagation to iteratively adjust the network's weights and biases, thereby optimizing it over time. This continuous process enables the model to learn complex patterns and variations in facial features so that it becomes possible accurately differentiating one person from another.

V. Factors affecting Face Recognition Performance

The process of collection and preparation of the dataset would, firstly involve training fitting model for face recognition. Many researchers often collect several pictures with faces of various people. 2 They are then labelled and annotated so as to identify the people who appear in them. This data set becomes the basis for training one of the most accurate models. The next step is training, deep learning techniques are applied here. Convolutional neural networks (CNNs) have been widely adopted as architecture at this stage. CNNs have some layers to assist in extracting useful features from the input images.

A. Dataset characteristics

In order to make sure that face recognition deep learning models will be trained and reached with proper assessment it is necessary to get a range of diverse geographically, age company-wise represented dataset. This dataset should involve many lighting conditions, occlusions, poses and expressions that will allow to generalize it for real-world situations. Balancing the dataset by gender, age and ethnicity is also crucial to address biases that can negatively impact how well an algorithm performs. The task of building such a dataset is difficult but very important for the development of effective and accurate face popularity systems.

V. COMPARESION OF ML AND DL APPROCHES

The following discussion goes into details how system and deep learning approaches the usage of facial recognition. It provides a general picture of the basic principles and approaches associated with it emphasizing on their efficacy in terms of identifying different people's faces. On the one hand, using traditional machine learning approaches has some advantages since more sophisticated techniques may help improve accuracy rates greatly at a cost of increased responsibility. This is especially the case with complex jobs such as face identification in which intricate solutions are required to produce best results.

Table 1: Groups of comparative reviewed papers

Reference	Focus	Methodology	Aim and Objectives	Contribution	Achievements
Group 1: Deep Learning Emphasis					
[2]	Methods for Identifying Faces	Emphasis on DL	Investigate and analyze the application of DL in facial recognition.	Provides insights into DL techniques for facial recognition.	Enhanced understanding of deep learning applications in facial recognition.
[3]	Comprehending Facial Recognition using Deep Learning	DL frameworks	Explore DL frameworks for understanding facial expressions.	Enhances understanding of DL applications in facial expression recognition.	Improved comprehension of deep learning frameworks for facial expression analysis.
[4]	Deep Learning-based Face Recognition	DL-based approach	Evaluate the role of DL in face recognition.	Contributes to the understanding of DL-based approaches in facial recognition.	Advancements in the understanding of deep learning's role in facial recognition.
[5]	Utilizing Deep Learning and Field-Programmable Gate Array (FPGA) for Face Recognition In-depth Evaluation of Deep Learning for Face Recognition	Ethnicity Identification	Assess the efficacy of DL and FPGA in ethnicity identification.	Advances knowledge on DL and FPGA application in ethnicity identification.	Exploration of novel applications for DL and FPGA in ethnicity identification.
[13]	Deep Learning for Face Detection and Recognition	DL's critical analysis	Critically assess the role of DL in face detection and recognition.	Offers a critical perspective on the strengths and limitations of DL in face recognition.	Critical insights into the role and challenges of deep learning in facial recognition.
[20]	Methods for Identifying Faces	Face recognition with DL	Investigate the application of DL in face recognition.	Contributes to the knowledge of DL applications in face recognition.	Advancements in the understanding of deep learning's role in facial recognition.
[22]	Comprehending Facial Recognition using Deep Learning	DL-based detection	Explore DL-based methods for facial detection and recognition.	Offers insights into DL-based methods for facial detection.	Exploration of deep learning-based techniques for facial detection and recognition.
Group 2: Enhanced Faster RCNN for Face Detection					
[6]	Improved Faster RCNN for Facial Detection	Enhanced Faster RCNN	Suggests improved The Faster RCNN algorithm is utilized for the purpose of face detection, although no specific information regarding its accuracy is provided.	Proposes enhancements to Faster RCNN for facial detection.	Introduces potential improvements to the Faster RCNN algorithm for facial detection.
[17]	Comparative analysis of machine learning-based approaches	ML-based detection	Compares machine learning-based techniques for face detection, without providing specific accuracy metrics.	Analyze and compare ML-based methods for face detection.	Comparative insights into machine learning approaches for facial detection.
[18]	An Analysis of Machine Learning versus Deep Learning for Face Recognition	ML vs. DL comparison	Performs a comparative examination of machine learning (ML) and deep learning (DL) algorithms in the specific domain of face recognition, but does not furnish exact accuracy metrics.	Compare ML and DL algorithms for face recognition.	Comparative study between ML and DL approaches in facial recognition.
Group 3: Review and Challenges					
[1]	Identifying Presentation Attacks	Survey of PAD methods	Examines Presentation Attack Detection techniques for face recognition, omitting specific accuracy metrics.	Survey and review Presentation Attack Detection methods.	Overview of existing Presentation Attack Detection methods.
[7]	An exhaustive analysis of facial recognition systems	Face recognition systems	Gives a thorough analysis of face recognition systems without providing exact accuracy information.	Conduct an in-depth analysis of facial recognition systems.	Comprehensive analysis of various facial recognition systems.
[10]	Security surveillance systems can employ multidimensional face recognition techniques	Altered faces recognition	The proposal suggests acknowledging surgically modified faces, but does not provide specific details regarding its accuracy.	Propose the use of multidimensional face recognition for security surveillance.	Introduction of multidimensional face recognition for security purposes.
[12]	Advantages and Difficulties of Facial Recognition and Detection	Challenges overview	Explores the advantages and difficulties associated with face recognition/detection, without providing specific accuracy measurements.	Explore advantages and challenges in facial recognition/detection.	Overview of benefits and challenges in facial recognition and detection.
[14]	Obstacles and Approaches for Facial Recognition Systems	Detection challenges	Explores the difficulties and techniques involved in face detection, without providing details about the level of accuracy.	Investigate challenges and approaches in face detection.	Examination of challenges and potential solutions in facial recognition systems.

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VI. Conclusion

Finally, this paper presents face detection through the implementation of machine learning and deep learning techniques. Comparing the two, it is clear that deep learning was superior in accuracy measures and capacity to handle large datasets thereby making it favorable when an enterprise scales up its performance on more complicated tasks of facial recognition. So, no matter how complicated these systems might be designed the process of their implementations may get simpler if using a set of tools which allow to develop such models efficiently. Integrating modern technologies to develop face recognition programs, optimizes security measures because they can achieve accurate results using advanced algorithms supported by big datasets during the development stages thus reducing bias effects arising when smaller dataset inputs are utilized which cause errors as a result of no diversity being employed while training predictive token-target-mapping functionalities within AI system modules geared towards recognizing faces almost instantly without compromised

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