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Title HOW MACHINE LEARNING ALGORITHMS WORK IN FACE RECOGNITION SYSTEM? A REVIEW AND COMPARATIVE STUDY

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How Machine Learning Algorithms work in Face Recognition System? A Review and Comparative Study

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Abstract - In the continuous development in field of science and technology, One of the most important AI approaches, computer vision is used in a wide range of fields. Computer vision involves the development of algorithms and techniques that enable computers to process and analyze images and videos to recognize objects, patterns, and other visual data. Computer vision techniques help computers to sight and understand content of digital images. Facial Recognition is an area where computer vision technology is used. It is the most intensely studied area in computer vision more than five decades. It has many applications like Automated Surveillance Systems, Security Monitoring System, Finding of Missing Person and Victim Identification and so on. In these days, it is mostly used for marking attendance of students and employees in colleges and organizations. smart attendance systems are valuable tools for organizations looking to improve attendance management, reduce administrative workload, and increase efficiency. This research of several machine learning techniques like Convolutional Neural Network, Support Vector Machine, Principal Component Analysis, Eigen face, Fisher face etc, many of which have been employed by other writers in Smart Attendance System (SAS) employing Facial Recognition, is extensive.

Keywords –PCA (Principal Component Analysis), SVM (Support Vector Machine), CNN (Convolutional Neural Network), Haar Cascade, Local Binary Pattern, Eigen face, Fisher face Algorithm

I. Introduction

Face is an important characteristic used by humans for identity recognition. Facial Recognition is one of the most developed techniques in computer vision area. A face recognition algorithm is a computer program

that analyzes and recognizes human faces within an image or video stream. The algorithm uses a combination of image processing techniques, machine learning, and artificial intelligence to identify and verify individual faces by comparing them

to a database of known faces. Face Detection and Recognition Software have a basic method named as Face Detection Algorithm. This algorithm works under the Artificial Neural Network. There are different types of face recognition algorithms, including 2D, 3D face recognition, and thermal face recognition. Each algorithm has its own set of benefits and restrictions, and particular application and use case determine the algorithm to be used. These algorithm works on 3 steps: (1) Detection of faces in real-time image or video; (2) Extraction of features from an image and calculate mathematical model for features; (3) Comparison of models with databases to validate a person's identity. Various algorithms are developed for face detection and recognition in the last three to four decades to obtain a strong evaluation of performance of algorithms based on different categories of images. The purpose of this study is to compare various machine learning face recognition algorithms and to assess the differences between them and to talk about addition of PCA with different - different algorithms and at last, which algorithm is the best suited for developing the Face Recognition System.

II. Workflow of Face Recognition System

When system is activated, it asks for the inputs which include the live images of students, name and Id. After storing and training system, it will be ready for use that is used to track images and produce a spreadsheet of attendance report.

- **Image Capturing:** First it captures the image of the students in real time.
- **Face Detection:** In face detection, it detects the face from a real time image containing many more people's faces, using different type of algorithms like OpenCV, Haar Cascade, OpenCV, DNN (Deep Neural Network), using Dlib toolkit, Multi-Task Cascaded Convolutional Neural Network (MTCNN), Yolo, Face net etc.
- **Pre-processing:** After detection, the face will be pre-processed. Face Recognition Technology uses 2-D images rather than 3- D images. This is because 2-D images are more readable. The images must have same resolution, brightness, levels of zoom, orientation, etc. It is additionally known as "feature normalization".
- **Feature Extraction:** After normalizing the face image, the algorithm gathers useful information from the facial photos, means it extracts features from face. Facial Feature Extraction is a process of extracting face features like eyes, difference between eyebrows, nose, mouth, etc. from human face images by converting them into vectors.
- **Matching:** In this step, we will match features which are extracted from captured image with the database using face recognition algorithms. If it is validated

successfully, it returns the user's name with id.

III. Literature review:

We have reviewed the significant research papers in the field published during 2010-2022, mainly from the years from 2017 to 2022 with. The main focal point was papers selected from the reputed publishers such as IEEE, Elsevier, Taylor & Francis, Science Direct, Springer and IJRET. Researcher were reviewed more than 60 papers on various Face Recognition Systems. This indicates that this review focused on the latest publications and all possible approaches to develop a Smart Attendance System using Face Recognition. Keywords used for searching these review papers, are "Face Recognition", "Deep Learning", "Machine Learning", "Convolutional Neural Network - CNN", "Haar Cascade", "Deep Learning and Architectures", "Face Detection", "Feature Extraction", "Image Classification", "Segmentation", "Face Recognition Algorithm", "Eigen Algorithm", "Fisher Algorithm", "OpenCV Library", "D-lib Library", "Relationship between students' attendance and their performance", "Python", "MySQL Workbench", "Support Vector Machine Algorithm - SVM", "Principle Component Analysis Algorithm - PCA" etc.

1. **Viola-Jones algorithm:** In 2001, Michael Jones and Paul Viola designed it and has since become widely used in various industries and applications. The algorithm works by using a set of Haar-like features to identify regions of an image that are

likely to contain a face. Haar-like features are rectangular patterns of pixel intensities that are computed at various scales and positions in image. To decide whether each candidate region has a face or not, the system then employs a series of classifiers that were trained using a modified version of the Adaboost method. This can sometimes produce false positives or miss faces in challenging lighting conditions or when faces are partially occluded. A study done by (**Poornima et al., 2018**) have investigated three different modules in his research. First one is Attendance system based upon Face Recognition; second one is Voice Converted Output which tells about all the absent students and third one is Gender classification Module which classifies the male and female students and tally the number of pupils in the class, both male and female, during lecture time. In face recognition system, the Viola Jones Algorithm was used in face detection process and Principal Component Analysis (PCA) algorithm was used for feature extraction. Corresponding names of students are fetched from the database of the matched images and rest students are marked as absentee. Microsoft Speech API was used for the conversion of the names of absentees into voice. Voice output ensures that the attendance is marked rightly or not. For gender detection,

author used Artificial Neural Networks, Gabor Wavelets and Support Vector Machine. In this paper, author achieved 83.33% accuracy. In a different article (**Ismael et al., 2020**) developed a Face Recognition System based on Viola-Jones algorithm depending on python. This software was designed to recognize the faces of persons entering into the premise from the stream of pictures or video feed. Viola-Jones face detection framework was used in this project with the help of python. This project works in two steps which are “detect the human face using computerized camera” and “recognition and matching of face from the database images”. In this project, OpenCV computer vision library was used to focus on real time image processing & easy implementation and three algorithms Eigen faces, Fisher faces and LBPH were used. The main objective of this software was to identify the authorized person to enter into a premise with face recognition. A study organized by (**Bhattacharya et al., 2018**) developed a Smart Attendance System for classroom attendance. He used a video sequence for input method. In this paper, Viola & Jones methodology is used in face detection and D-Lib library is used to track the face in frames, which resulted into face logs. Convolution Neural Networks have been used for

classifying the images in this project. In the case of similar matchings from database, author proposed a list of names to be displayed on screen with higher matching at top and student has to select his/her own name for the attendance. This project had limitations regarding to facial expressions, lighting conditions and different angles of images even though it showed a satisfactory result. A researcher (**Vera Wati et al., 2021**) proposed two model Individual attendance recognition and group face recognition in which face detection based on Viola Jones method and feature extraction based on Gabor Wavelet which used wavelengths parameters for extraction. To calculate the value of accuracy, recall, and precision, a confusion matrix is produced. The recall value is used to gauge how well the system is able to relearn knowledge. The precision value is created to assess the consistency between user-requested information and system-generated outcomes. The research achieved 88% accuracy, 75% recall, and 97% precision score for group face recognition, which is the better outcome.

2. **Local Binary Pattern Histogram:** It was first introduced by Ojala et al. in 1996 and has since been widely used in various applications, including face recognition. The algorithm works by dividing an image into

small regions, typically 3x3 or 5x5 pixel blocks, and based on comparing the intensity of the centre pixel to the pixels around it, creating a binary code for each block. After computing the binary codes for each block in the image, a histogram of the frequency of occurrence of each unique binary code is computed to represent the texture of the image. It is also robust to illumination changes and can handle non-rigid deformations of objects. However, it may not perform well in cases where the texture patterns are too complex or the image resolution is too low. A study investigates by (Hwa Sheng Ho et al., 2021) used Face Recognition Algo, Local Binary Patterns Histograms, and implemented it on Raspberry Pi for smart Attendance System. For face detection, he used Haar Classifier based upon Viola & Jones Algorithm. Haar is capable of extracting 3 types of features from images which are edge, line and four-rectangle. Adaboost was used for eliminating irrelevant features and Cascading Methods was used to reject irrelevant image. For Face Recognition, author used LBPH algorithm and had a major focus on it in his project. In this system, attendance of students was marked one by one, so it was a very time-consuming process. Latest version of Raspberry Pi, is able to make system powerful and faster processing. In a

different article researcher (Anirudha B Shetty et al., 2021) compared 2 face recognition technique Haar Cascade and Local Binary Pattern are improved for categorization. As a result, although though Haar Cascade takes longer to execute than Local Binary Pattern, it is more accurate. The accuracy of the LBP classifier is 94.74%, and that of the Haar cascade is 96.24%. The classifiers' drawback is that they cannot recognize children's faces. One of the researchers (Serign Modou Bah et al., 2019) proposed a method in order to address some of the problems impeding face recognition accuracy, this study introduces a novel approach based on the Local Binary Pattern (LBP) algorithm and high-end image processing methods such as Contrast Adjustment, Bilateral Filter, Histogram Equalization, and Picture Blending. Improving the LBP codes will improve the accuracy of the face recognition system. The quality of the input face images and the training/reference images used in the face comparison process have a big impact on LBPH. We took use of the following image quality characteristics of our input and reference face photos in order to acquire the highest quality images that will disclose better details of image features for more precise feature extraction and comparison. For FRS, this technique is

particularly dependable, accurate, and durable.

3. **Convolutional Neural Network:** A Convolutional Neural Network is a deep learning algorithm mostly used for image recognition, object detection, and other computer vision task. CNNs are built to automatically and adaptively learn feature spatial hierarchies from input images. Convolutional, pooling, and fully linked layers are among the many layers that make up CNNs. The general approach for using CNNs for face recognition involves training a network on a large dataset of labeled faces, and then using the network to take out features from new faces and matching these features to a database of recognized faces. One advantage of using CNNs for face recognition is their ability to learn features that are strong to variations in lighting and facial expression. Additionally, the network may still struggle with recognizing faces in certain conditions, such as when the face is partially occluded or when the person is wearing a mask.

One of the researchers (**Radhika et al., 2018**) conducted a research study on Face Recognition Research using CNN, SVM and MLP algorithms. She compared all these Algorithms and came on a conclusion that CNN algorithm gives highest Accuracy among all algorithms, she used. Author completed face recognition

process in three steps. First step was face detection; in which author used deep neural network which was incorporated with Single Shot Detector with ResNet. During the second step which is feature extraction, author used PCA and LDA algorithms. PCA converts the images into Eigen faces and reduces the size of image by removing unwanted portion of images. LDA algorithm uses 2-D vector to represent the faces. Both of these algorithms use Covariance matrix for extracting the facial features. The third step was face matching in which researcher compared CNN, SVM and MLP algorithms and they gave 98%, 87%, 86.5% accuracy respectively at the time of testing. And at the time of face recognition, SVM and MLP algorithms gave 56% accuracy while CNN algorithm gave 89% accuracy. So, after the study of this research paper, a good quality camera module could help in achieving the higher accuracy and additional details of students could be displayed along with the attendance status. A study done by (**Shamrat et al., 2021**) to work on with the real image in a video series, many Researchers use Convolutional Neural Network area of deep learning. This CNN technique increases the accuracy of face detection. Author used Max Pooling Process in CNN which takes LFW dataset from Kaggle for validating

and training. This dataset had 13000 photos of 1680 people in unique angle. Author achieved 95.72% accuracy for training data.

4. **Principal Component Analysis:**

Large datasets can have their dimensionality reduced using the statistical technique known as principal component analysis, while retaining as much information as possible. In face recognition systems, PCA is an extensively used technique. In a typical PCA-based face recognition system, goal is to reduce the dimensionality of face images while retaining the most data possible. To recognize new face image using PCA, the image is first projected onto the subspace defined by the top k eigenvectors. This projection results in a set of coefficients that represent the image in terms of the principal components. These coefficients are then compared to the coefficients of known faces in a database using a distance metric, such as the Euclidean distance or cosine distance. The face image is then classified as the person with the closest matching coefficients in the database. PCA-based face recognition systems have been widely used and can achieve good accuracy, particularly when the dataset is well controlled and has few variations in lighting, pose, and facial expression. However, they may struggle with recognizing faces

in more complex and diverse datasets, where other techniques such as CNNs may be more effective.

One of research done by (**Rekha et al., 2018**) where creating a facial recognition system was this paper's primary goal based upon Eigen database and author used PCA algorithm using MATLAB for face recognition. She also explained PCA algorithm and its working. She used PCA because it removes extra un-useful information from the picture. It extracts only facial features and converts face structure components into orthogonal Eigen faces, which is known as Eigen Face Technique and face components are called Principal Component or Eigen Faces. PCA algorithm extracts less dimension features of a face structure as it reduces the dimensions and unwanted components of an image. In this paper, author used "component" word for features. In this algorithm, a test image is compared with training test by calculating the distance between feature vectors. This algorithm needs full frontal image, otherwise it would give poor performance but it is a secured method as compared with the traditional method. Another researcher (**Winarno et al., 2022**) proposed a hybrid method use Principal Component Analysis and Convolutional Neural Network. This combination gave more accurate

result for feature extraction. It was a framework system that combined face detection and face recognition. This system was working in the steps of data acquisition, face detection, pre-processing of image, extraction of features and classification processes. In this process, camera module creates a region of interest for identifying the faces and for removing the unusual background. The CNN was used to convert a 2D face image into 3D face image. PCA was used for feature extraction. For the classification process and to determine the degree of similarity between features in order to give a more accurate result, the Mahalanobis Distance method was utilized. Face Recognition using PCA + CNN was able to give higher accuracy of ~98% rather than only PCA. One of the researchers (**Sharma et al., 2020**) Used a machine learning algorithm and principal component analysis, this work tries to create a face recognition method (PCA). Support vector machines, Naive Bayes, multilayer perceptron's and linear discriminant analysis are used in the experiments. The ORL dataset is utilized for experimentation. It has achieved recognition accuracy of 97% and 100% using PCA and linear discriminant analysis, respectively.

5. **Support Vector Machine:** SVM is a supervised machine learning

algorithm used for regression and classification analysis. Finding the hyperplane that best categories the data into distinct groups or forecasts the values of the target variable is how SVM operates. SVM can be used for face recognition as a classification algorithm to classify face images into different categories, such as different people or different facial expressions. SVM operates by identifying the hyperplane that best divides the data into various classes. In face recognition, SVM can be used as a classification algorithm to classify face images into different - different categories, such as different people or different facial expressions. For example, an SVM can be trained to classify face images into two classes: a positive class, where the image corresponds to a particular person, and a negative class, where the image corresponds to someone else. A researcher (**Shanshan Guo et al., 2016**) represented a hybrid model using SVM with CNN. In this study, researcher combine Support Vector Machine and Convolutional Neural Network to recognize facial images. CNN is used for a feature extractor to automatically gather outstanding features. We first train our Network using the target dataset after pre-training it using ancillary data in order to extract more hidden face features. Lastly, SVM is used as our classifier to determine all the classes,

as opposed to CNN. SVM will more effectively identify faces when facial features from CNN are used as input. The model that CNN and SVM combine has a high recognition rate and requires minimal training time. The advantages of this method are confirmed by studies using the FERET and ORL datasets. In the future, it will use a more complicated CNN with additional optimization techniques and a larger training set to balance recognition rate and training duration. In other articles written by (Shi et al., 2020) proposed a 3D face recognition technique that combines LBP and SVM is proposed. The three-dimensional facial depth image's feature data is first extracted using the LBP algorithm, and is then classified using the SVM algorithm. The LBP operator's radius is set to 2, there are 12 neighborhoods, and the SVM employs a radial basis kernel function. Experimental findings demonstrate that the algorithm is more accurate and takes less time.

6. Eigenfaces Algorithm: Eigenface algorithm is a popular facial recognition algorithm that uses principal component analysis to extract the important features from a set of face images. These features, or eigenfaces, are then used to represent each face in the dataset as a linear combination of eigenfaces. During recognition, an additional representation of a new face image is

a linear combination of eigenfaces. and compared with the eigenface representations of the faces in the database. Eigenface algorithm is a useful method for facial recognition in certain scenarios, but may not be the best choice for more complex and diverse datasets. Alex Pentland and Matthew Turk applied the Eigenface method for face categorization, which was developed by Sirovich and Kirby in 1987. An article written by (Ibnu Utomo Wahyu Mulyono et al., 2019) proposed a method to recognize faces. Eigenface was employed to lower the number of dimensions and identify the ideal vector for distributing the facial picture inside the facial space. This study aims to assess how well the PCA Eigenface method performs when used to identify human face images from various databases, each of which presents its own set of difficulties, including poor lighting for facial images, wide variations in expression, and the wearing of accessories like glasses. With an average identification rate of around 85%, the recognized accuracy varies widely, ranging from 100% to 67% in each database. In other articles written by (Ega Bima Putranto et al., 2016) In this study, the eigenface feature extraction output is classified using naive Bayes to predict the face. The addition of the normalization z-score sharpens the accuracy. Cross

validation (k=10) is used to divide the 200 datasets into training and testing groups so that the performance of the proposed approach can be evaluated. The findings demonstrate that the suggested strategy is capable of up to 70% face image prediction. Also, by including the normalization Z-Score, the prediction accuracy increased to 89.5%. (In average).

7. **Fisherfaces Algorithm:** Fisherfaces is a popular algorithm used in face recognition tasks. It is a linear discriminant analysis (LDA) based approach, which seeks to identify a low-dimensional subspace that increases the separation between classes while decreasing the within-class dispersion. The resulting low-dimensional subspace, known as the "Fisherfaces," can be used to represent the training images for each person in a compact and discriminative way. During recognition, a test image is projected onto the Fisherfaces subspace and compared to the projections of the training images. The identity of the test image is determined by finding the closest match among the training images.

Fisherfaces is a powerful technique for face recognition and has been used in various applications such as surveillance, access control, and biometrics. Belheumeur first presented the fisherface face recognition technique in 1997. Researcher (**Mustamin Anggo et al., 2018**) used fisherface algorithm for face recognition. The photograph of the Papuan's face served as the study's data source. In Fisherface algorithm researcher used linear discriminant analysis and principal component analysis. Because of its extremely difficult and intricate computing procedure, the Fisherfaces method's computation difficulty for face identification becomes problematic. Another article written by (**Banu Wirawan Yohanesy et al., 2018**) compared Fisherfaces and LBP on face recognition system. With more training data, both Fisherfaces and LBP systems' accuracy rates often rise, while LBP's accuracy is higher than Fisherfaces'. LBP's prediction rate in dataset testing is 94.89%, which is greater than Fisherfaces' 91.05%. Moreover, LBP performs 88.9% better in video testing than Fisherfaces, which comes in at 79.3

IV. Comparison between different Face Detection Algorithms

Algorithm	Advantage	Disadvantage
Viola-Jones algorithm	This algorithm is so simple and can run in real-time. Capture Face is more accurate.	Computationally complex and slow. Longer training time.
Local Binary Pattern	Computationally simple and fast.	Low accuracy.

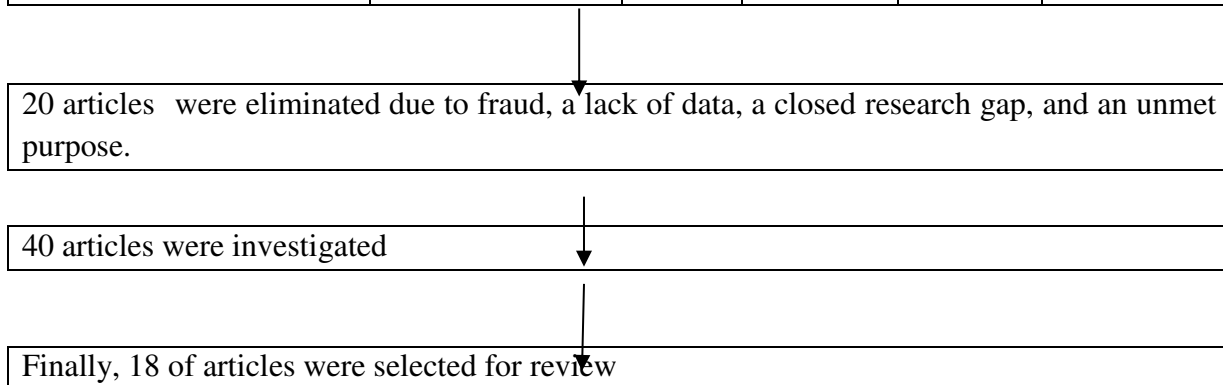
	Shorter training time.	The level of recognition is still lacking.
Principal Component Analysis	Fast simple and very popular. Smaller learning time. Feature reduction.	Very sensitive to lighting or changes.
Support Vector Machine	High accuracy. It can handle many features.	Training time is long when using large datasets.
Deep Learning (CNN)	Fast Computing Rate. The best level of accuracy.	High level of complexity. Difficult to Implement.
Eigen faces	It is simple and fast.	Sensitive to light. Highly Sensitive to facial expression.
Fisher faces	Less sensitive to facial expression.	It is slightly more complex.

V. Research Methodology

• Search Criteria and Selection Strategy

This review paper searching was performed electronically to discover peer-reviewed papers from various publishers. The selected articles from journals and conference proceedings span a wide range of study areas, including Computer science, Artificial intelligence, Machine learning, Mathematics, Deep learning and Computer vision. In this analysis, which included 60 papers in total, we examined 15 journal papers. It includes some journals like IEEE Transactions on Image Processing, International Journal of Computer Vision, IEEE Access, Journal of Artificial Intelligence Research, Indonesian Journal of Electrical Engineering and Computer Science and some conferences are like International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), IEEE International conference on Information and Automation and International Seminar on Research of Information Technology and Intelligent Systems etc.

Name of Publisher	Taylor & Francis	IEEE	Elsevier	SAGE	IJERT
No. of Articles studied	10	15	15	10	10



VI. Conclusion

Several scholars have looked into the present literature and found that the development of attendance systems has a significant impact on information technology innovation. Automated attendance systems are quite popular and used in many different fields because they do not have the shortcomings of traditional ones. The findings, the kind of technology employed, and the application domain categorization have all been taken into consideration while categorising these studies. So, researcher have reviewed the significant research papers in field of computer vision published during last 7 years 2015–2022. After reviewing above mentioned 15 research papers and studying more than 100 papers related to “Marking Attendance Using Face Recognition System”, we found that Haar Cascade is the most effective way of face detection, PCA algorithm is the best for extracting the features of a face structure as it reduces the dimensions and unwanted components of an image, Convolutional Neural Network algorithm also contributes in attendance marking based on Face Recognition System by providing a strong classifier, for static images, real-time camera video, and dynamic video, the Python language and Dlib approach (an open-source library with a Python interface) provide improved face identification and recognition.

VII. Implications

In present scenario of technology revolution, face recognition technology can play a major role in a person’s identity verification

in various organisations such as schools, hospitals, government agencies, and non-governmental organisations for security enhancement and easier approach. In these projects, face recognition is used for marking students’ attendance. organizations. Similarly, it can be used for validation of users’ identity for availing any service or entering into various premises. We think that this research will keep looking into more studies to highlight important factors in this field, such as difficulties, research trends, other technologies that have been implemented, and so on.

VIII. Future Prospects

The projects of Smart Attendance System give a basic idea for validation of a person’s identity using face recognition technology. All of the above-mentioned projects were tested in an environment where a small database and limited featured devices were available. These systems were also not able to perform well in case of low image quality which includes less pixels, low brightness, angular image, facial accessories, distance from camera etc. which resulted into lower accuracy. In future, these systems can be improved in a way to handle large database records and to eliminate lower accuracy problem by using high-definition camera modules based on Artificial Intelligence with auto-correction of images. These systems can also add some additional features like communication with parents, acknowledgement of attendance through email etc. Also, this system used a large training time which needs to be reduced for working with futuristic requirement.

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