Seminar Report

On

A Survey on Face Recognition Technology

By

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Under the guidance
of

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MIT-World Peace University (MIT-WPU)
Faculty of Engineering
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*** 2022-2023 ***

A SURVEY ON FACE RECOGNITION TECHNOLOGY

MIT-World Peace University (MIT-WPU)

Faculty of Engineering

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CERTIFICATE

This is to certify that Ms. Ayushi Prasad of B.Tech., School of Computer Engineering & Technology, Trimester – VI, PRN. No. 1032200356, has successfully completed seminar on

A Survey on Face Recognition Technology

To my satisfaction and submitted the same during the academic year 2022 - 2023 towards the partial fulfillment of degree of Bachelor of Technology in School of Computer Engineering & Technology under Dr. Vishwanath Karad MIT- World Peace University, Pune.

Mrs. Sushila Palwe — Seminar Guide

Dr. Vrushali Kulkarni — Head, School of Computer Engineering & Technology

A SURVEY ON FACE RECOGNITION TECHNOLOGY

Dr. Vishwanath Karad
MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

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MITWPU/SCET/BTECH/Seminar Report

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Ayushi Prasad

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1. ABSTRACT

A subset of computer vision known as face recognition employs algorithms to recognize and authenticate people by looking at their faces. The technique creates a distinctive template or representation of the face by detecting and analyzing several facial features, including the eyes, nose, mouth, and jawline. The person is then identified by comparing the template to a database of previously stored templates. Applications for the technology include access control, user authentication, and security and surveillance. Deep learning models that attain high accuracy and robustness to changing settings have enabled substantial advancements in face recognition technology in recent years. However, the technology also prompts worries about misuse, data security, and privacy. Therefore, it is crucial to create moral and legal frameworks that will oversee the application of facial recognition technology and guarantee that it is done so in a responsible and open manner.

Keywords used: Face Recognition, Algorithms, Technology, Deep Learning

2. INTRODUCTION

A sort of biometric technology called face recognition employs algorithms to recognize and confirm a person's identity based on their facial traits.

Due to its capacity to deliver secure and practical authentication for a range of applications, including unlocking devices, gaining access to protected facilities, and confirming identities at airports, this technology has grown in popularity over the past several years.

Face recognition entails taking a picture or video of someone's face and examining it to identify distinctive traits like the distance between their eyes, the shape of their jawline, and the curve of their lips. The identity of the person is then established by comparing these features to a database of recognized faces.

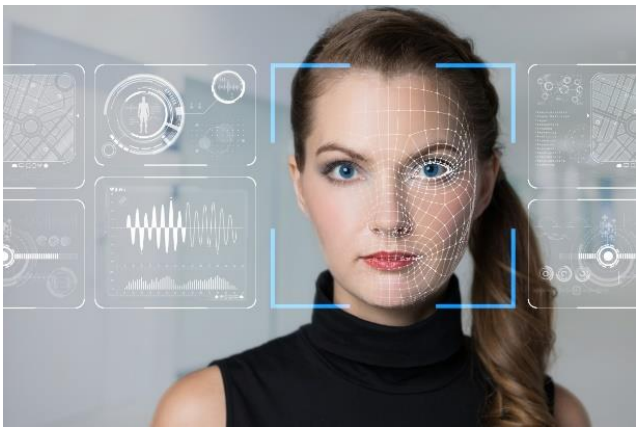

Fig 1. Face Recognition

2.1 IMPORTANCE OF FACE RECOGNITION TECHNOLOGY IN INDUSTRIES

Face recognition systems are widely used in security and surveillance applications. Face recognition technology is being used by law enforcement agencies to identify criminals and suspects. It can also be used to identify missing persons and victims of crimes. Face recognition can also be used as a biometric authentication method for various purposes, such as unlocking smartphones, accessing bank accounts, and entering secure buildings. Face recognition system can be used in healthcare to identify patients and their medical records, as well as to detect and diagnose certain medical conditions based on facial features. Face recognition technology can also be used in educational settings to track attendance and monitor student behaviour. Face recognition systems are also used in airports and other travel hubs to verify the identity of passengers and prevent fraud.

In summary, face recognition technology is a rapidly developing topic with a wide range of possible uses.

2.2 REVOLUTIONIZATION

The introduction of face recognition technology has revolutionized the way individuals are identified and has brought many benefits, such as:

2.1. Increased accuracy and speed: Face recognition technology can accurately and quickly identify individuals from large databases or real-time video streams. This has made it easier and faster for law enforcement agencies to identify suspects and for businesses to authenticate customers.

2.2. Enhanced security: Face recognition technology can be used to improve security in various settings, such as airports, border checkpoints, and public events. By quickly identifying individuals who pose a security risk, face recognition technology can help to prevent crime and ensure public safety.

2.3. Improved convenience: Face recognition technology can be used to simplify and streamline various processes, such as unlocking smartphones, accessing secure areas, or making payments. This has made it more convenient for individuals to access services and facilities.

2.3 BACKGROUND

The history of face recognition can be traced back to the 1960's. But then, the technology was limited by the processing power of the time and complexity of recognizing faces with varying lighting conditions, angles and expressions.

In the 1990s, the development of more powerful computers and algorithms led to significant progress in face recognition technology. This allowed for the creation of the first practical face recognition systems, which were primarily used for security and law enforcement applications.

Over the past few decades, face recognition systems have continued to evolve and improve, driven by advances in computer vision, machine learning, and artificial intelligence. Today, face recognition systems are widely used in a various industries, including security, law enforcement, marketing, and personalization.

3. WORKING OF FACE RECOGNITION MODEL

Using specialized algorithms like Viola-Jones or deep learning models, the technology finds faces in images or video streams. To locate the face and its many features, including the eyes, nose, mouth, and jawline, the algorithms analyse the image.

The system then aligns the face to a common reference pose or orientation after it has been recognized. This procedure aids in adjusting for changes in stance, expression, and lighting.

Following that, the system extracts a number of elements from the aligned face image, including the separations between facial landmarks and the texture, colour, and form of the face. Then, a template or individual depiction of the face is made using these features.

To identify the person, the system compares the extracted template with a database of stored templates. Statistical techniques like Euclidean distance, cosine similarity, or machine learning algorithms like SVM, k-NN, or neural networks are frequently used to compare objects.

Based on the similarity rating or distance between the extracted template and the saved templates, the technology then makes a choice. The technology recognises the person if the score is higher than a specific threshold. The system rejects the identification or asks the user for additional verification if the score falls below the cut off.

4. LITERATURE SURVEY

8.1 Yu, Zhigang, et al. "Research on Face Recognition Classification Based on Improved GoogleNet." *Security and Communication Networks* 2022 (2022): 1-6.

In this research paper, the algorithm we have used is GoogleNet.

Google researchers created GoogleNet in 2014,. It is also known as Inception v1, and is a deep convolutional neural network design. Compared to other deep learning models, it has the following advantages:

Enhanced accuracy: When compared to other deep learning models, GoogleNet performs picture classification tasks with excellent accuracy while utilising fewer parameters.

GoogleNet has become a computationally efficient system thanks to the use of 1x1 convolutions, which help to minimise the amount of computations needed.

Faster training and inference times are possible thanks to GoogleNet's architecture, which is built to make the best use of GPU resources. This is accomplished by employing parallel branches in the network that have been designed to make effective use of GPU resources.

GoogleNet can be used for transfer learning, which entails modifying a previously trained network for a particular job. This can increase the model's accuracy while lowering the quantity of data and compute needed for training.

Accessibility: GoogleNet is freely accessible to researchers and developers all throughout the world as a component of various deep learning frameworks, including TensorFlow and PyTorch.

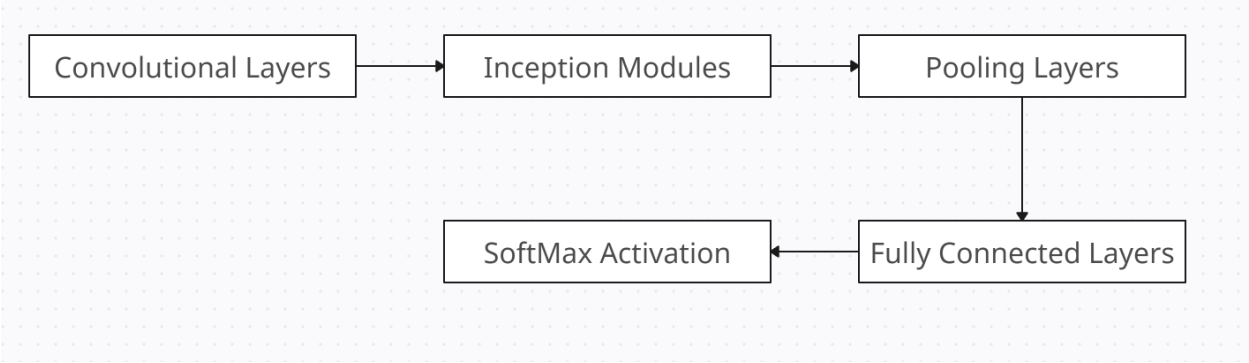

Fig 2. GoogleNet Architecture

Formulae:

Recall = $\frac{TP}{TP+FN}$

Precision = $\frac{TP}{TP+FP}$

F1 = $\frac{2*R*P}{R+P}$, where R is the Recall Rate and P is the Precision Rate

8.2 Teoh, K. H., et al. "Face recognition and identification using deep learning approach." Journal of Physics: Conference Series. Vol. 1755. No. 1. IOP Publishing, 2021.

In this research paper, the algorithm we have used is CNN.

Convolutional neural networks (CNNs) are a common technique in face recognition systems due to their ability to automatically acquire hierarchical characteristics from raw photo input. The CNN architecture consists of multiple layers of filters that learn different features from the input image.

CNNs can be used in face recognition systems to extract features from facial photographs that are independent of changes in stance, lighting, and expression. The input image can then be compared to a database of face template data using these attributes.

The process of face recognition using CNNs typically involves the following steps:

This involves detecting the presence of a face in an image and extracting the facial region.

Pre-processing is done on the retrieved facial image to eliminate noise, correct lighting, and normalize the image.

A CNN is then used to extract characteristics like edges, textures, and facial landmarks from the pre-processed image.

A distinct face template or representation is created for the input image using the features retrieved from the CNN.

The generated face template is then compared to a database of stored templates to identify the person.

CNNs have been shown to achieve high accuracy in face recognition tasks and can handle variations in facial appearance due to changes in pose, lighting, and expression. However, the accuracy of CNN-based face recognition systems can be affected by factors such as

image quality, occlusion, and variations in facial features due to age and ethnicity. As a result, it's crucial to properly assess these systems' performance and deal with any biases or errors.

8.3 Bah, Serign Modou, and Fang Ming. "An improved face recognition algorithm and its application in attendance management system." Array 5 (2020): 100014

In this research paper, we have used advanced image processing techniques such as Contrast Adjustment, Bilateral Filter, Histogram Equalization after preprocessing the input face images. The pre-processed input face images will then be divided into k^2regions. The LBP code is then computed by comparing each pixel in an image with its neighboring pixels. The central pixel value is then replaced with a binary value based on whether the neighboring pixels have a higher or lower intensity than the central pixel. The resulting binary code is then used to describe the texture of the image.

8.4 Li, Lixiang, et al. "A review of face recognition technology." IEEE access 8 (2020): 139110-139120.

This paper describes the development stages of face recognition technology and how have we reached here.

8.4.1 Early Algorithm Stage:

a) Principal Component Analysis (PCA): Principal component analysis, or PCA, is a statistical method used in data analysis and machine learning for feature extraction and dimensionality reduction. A high-dimensional dataset can have its dimensions reduced while still keeping the most important data points by using PCA. PCA is often used for feature extraction in image and signal processing, where the original dataset may have thousands or millions of dimensions. PCA can reduce the dimensionality of the dataset while keeping most of the important details, which makes the data simpler to view and interpret.

b) Linear Discriminant Analysis (LDA): Linear Discriminant Analysis, or LDA, is a statistical method used in data analysis and machine learning for supervised

classification and feature extraction. LDA is used to find a linear combination of features that will maximize the separation between classes in the dataset. To optimize the proportion of between-class variation to within-class variation, LDA reduces the initial feature space to a lower-dimensional space. The conclusions that follow from this are the maximization of the gap between the means of several classes and the minimization of variation within each class.

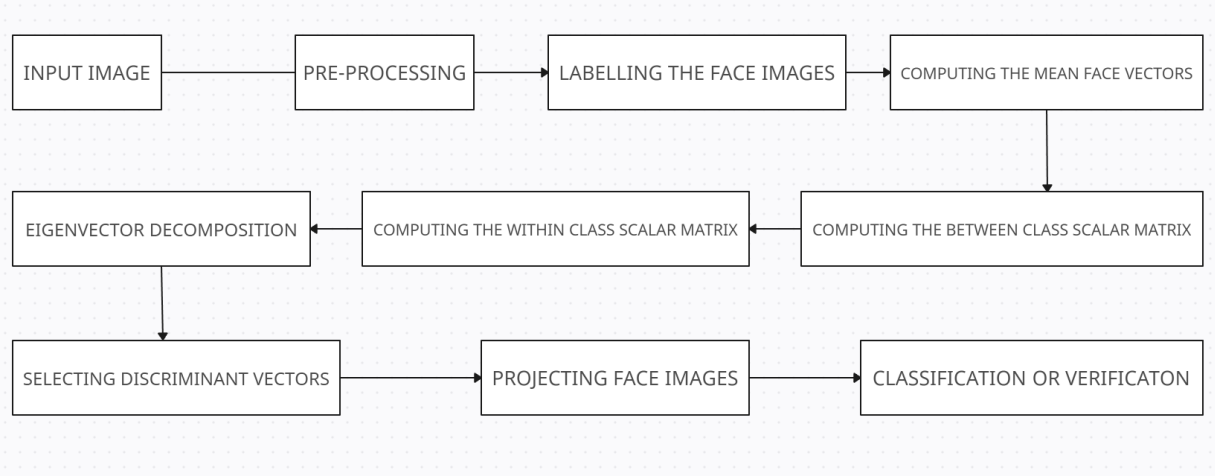

Fig 3. LDA Architecture

8.4.2 Artificial Features and Classifier Stage:

a) Support Vector Machine (SVM): SVM stands for Support Vector Machines, and it is a powerful supervised machine learning algorithm used for classification and regression analysis. Finding the ideal decision boundary that divides the data points of several classes in a dataset is the foundation of SVMs. In binary classification, SVMs locate the hyperplane that maximizes the margin, where the margin is the separation between the hyperplane and the nearest data points of each class. By applying a kernel function to transfer the input data into a higher-dimensional feature space, SVMs can also handle non-linear decision boundaries. They can generalize well to fresh data and are robust to outliers.

b) ADABOOST: For binary classification problems, a machine learning technique known as AdaBoost, short for Adaptive Boosting, is used. The

technique creates a strong classifier by mixing weak learners, which are straightforward classification models that only marginally outperform random guessing. AdaBoost has a variety of advantages, including the ability to handle highly dimensional data and combine weak learners into a potent classifier. Additionally, it can handle both discrete and continuous data and is relatively insensitive to outliers. AdaBoost is prone to noisy data and may overfit if there are too many iterations. Additionally, because it needs to gradually teach a number of weak learners, it takes longer to train than other algorithms.

8.4.3 Deep Learning: Deep learning has revolutionized the field of face recognition and is currently the most widely used approach in this area. In a face recognition system, deep learning models are trained on large datasets of labeled images to learn features that are specific to the faces. To extract features from facial photos, deep learning models like convolutional neural networks (CNNs) are utilized. These features are then put into a classifier to make predictions about the identification of the person in the image. One of the major benefits of deep learning in face recognition is its ability to handle variations in pose, lighting, and facial expressions. Deep learning models can learn to recognize faces even when they are partially occluded or viewed from different angles, making them more robust to real-world conditions.

8.5 Lal, Madan, et al. "Study of face recognition techniques: a survey." International Journal of Advanced Computer Science and Applications 9.6 (2018).

In this research paper, we go through various algorithms and techniques of face recognition technology that have evolved over the years.

8.5.1 Eigen Faces: Eigenfaces is a facial recognition algorithm that uses a mathematical technique called Principal Component Analysis (PCA) to analyze and identify faces in images. The goal of Eigenfaces is to represent each face as a linear combination of an assortment of fundamental patterns, or "eigenfaces," that are calculated using a substantial amount of training photos. The major components of the collection of

faces employed in the training set are essentially these eigenfaces. To recognize a new face, the algorithm compares the coefficients of the eigenfaces that represent the new face to the coefficients of the eigenfaces that represent the faces in the training set. The face with the closest match is considered to be the best match.

8.5.2 Artificial Neural Networks (ANN): Artificial neural network, also known as ANN is a kind of machine learning model that takes its cues from how the human brain is organized and operates. A network of interconnected, layered processing nodes makes up an ANN. The input layer receives the data, one or more hidden levels process it, and the output layer outputs the data. Every node in the network executes a straightforward mathematical operation and transmits the result to the following tier.

8.5.3 Gabor Wavelet: Gabor wavelet is a type of wavelet used in signal processing and image analysis. A Gabor wavelet is a complex wavelet that is defined by a Gaussian envelope function modulated by a sinusoidal wave. It is used in image processing and computer vision to analyze textures and features in an image.

8.5.4 Hidden Markov Models: Hidden Markov Models (HMMs) are statistical models used to model a sequence of events or observations that are believed to be generated by an underlying process with hidden states. The hidden states in an HMM can be deduced from the observations even though they cannot be seen directly. The model consists of two sets of probabilities: the emission probabilities, which represent the likelihood of detecting a specific observation given a hidden state, and the transition probabilities, which characterize the likelihood of migrating from one hidden state to another.

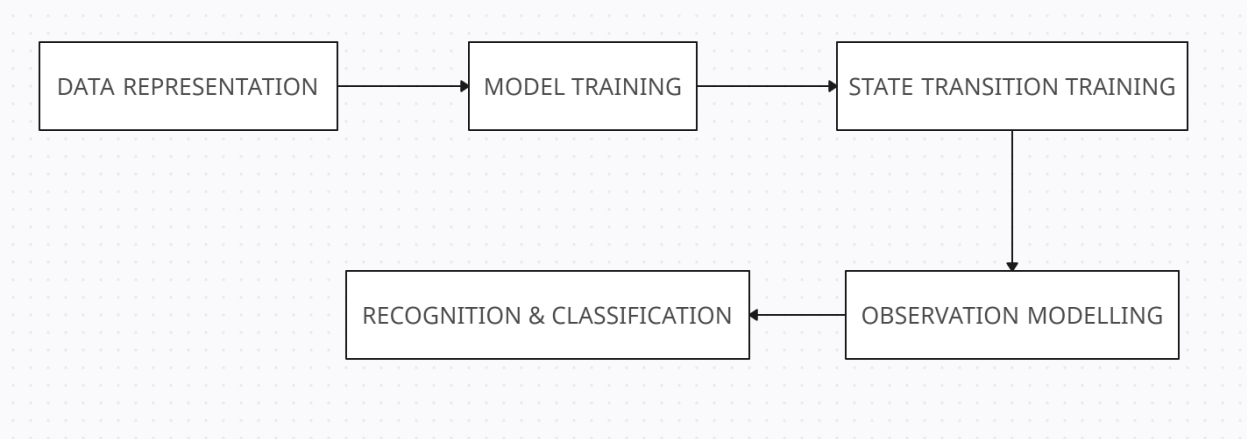

Fig 4. HMM Architecture

Sr. No.	Name of Research Paper	Proposed System	Techniques/Algorithms	Advantages/ Research Gaps
1.	Yu, Zhigang, et al. "Research on Face Recognition Classification Based on Improved GoogleNet." *Security and Communication Networks* 2022 (2022): 1-6.	This paper investigates the use of deep learning models in facial recognition software.	GoogleNet	To increase the width and accuracy of the network. It has high computational complexities and memory requirements.

2.	Teoh, K. H., et al. "Face recognition and identification using deep learning approach." Journal of Physics: Conference Series. Vol. 1755. No. 1. IOP Publishing, 2021.	Utilising deep learning, a face identification and recognition system is created.	CNN Approach	It reduces the number of parameters which in turn leads to faster calculation. It has high computational requirements and large amount of training data is required.
3.	Bah, Serign Modou, and Fang Ming. "An improved face recognition algorithm and its application in attendance management system." Array 5 (2020): 100014	It describes a practical and effective method for enhancing the accuracy of face recognition based on the local binary patterns algorithm.	LBP Algorithm, Contrast Adjustment Method, Bilateral Filter	Contrast Adjustment brightens the image. Bilateral Method removes texture, noise & fine details without blurring. LBP can miss some of the face's distinguishing characteristics.
4.	Li, Lixiang, et al. "A review of face recognition	The face recognition development process and related technologies, such as	PCA, LDA, SVM, AdaBoost, Small	PCA improve processing speed and save a lot of time and cost. Boosting

	technology." I EEE access 8 (2020): 139110-139120.	early algorithms, synthetic features and classifiers, deep learning, and other stages, will be discussed in this study.	Samples, Neural Networks	Algorithm can improve accuracy. PCA is sensitive to pose and lighting conditions.
5.	Lal, Madan, et al. "Study of face recognition techniques: a survey." Intern ational Journal of Advanced Computer Science and Applications 9. 6 (2018).	All face recognition techniques were thoroughly studied.	Eigen Faces, ANN, SVM, Gabor Wavelet, Hidden Markov Models	While eigen faces image features technique works well for frontal face identification, PCA is ideally suited when the dimension of features is larger. When an image's dimension is 150 or less, all other offer better outcomes. Gabor Wavelet and HMM perform better when combined with other techniques and may not perform that well independently.

5. DIFFERENT ALGORITHMS AND THEIR ADVANTAGES

5.1. Eigenfaces: Eigenfaces is one of the earliest and most popular algorithms for face recognition. It uses principal component analysis (PCA) to identify patterns in face images and then uses these patterns to classify and recognize faces. Eigenfaces is simple, efficient, and has a low computational cost.

5.2. Fisherfaces: A version of Eigenfaces called Fisherfaces makes use of Fisher discriminant analysis to more effectively divide face classes. Compared to Eigenfaces, it is more resistant to changes in lighting and position and is capable of handling non-linear alterations in face images.

5.3. Local Binary Patterns (LBP): LBP is a texture-based approach that extracts features from local regions of a face image. LBP is computationally efficient, robust to noise, and works well with small datasets.

5.4. Convolutional Neural Networks (CNNs): Using several layers, CNNs is a deep learning-based method for extracting information from facial photos. With huge datasets, CNNs have demonstrated state-of-the-art facial recognition performance.

5.5. Support Vector Machines (SVMs): SVMs are a machine learning-based approach that can learn to separate face classes based on features extracted from face images. SVMs are simple, efficient, and can handle non-linear variations in face images.

5.6. DeepFace: Facebook created the DeepFace face recognition system, which is based on deep learning. It achieves cutting-edge performance on various face recognition benchmarks by learning features from face photos using a deep convolutional neural network.

5.7. VGGFace: VGGFace is a deep learning-based face recognition technique that extracts features from facial photographs using a deep convolutional neural network. It is renowned for its great precision and resistance to changes in lighting and position.

5.8. GoogleNet: GoogleNet is a deep convolutional neural network CNN which was created by Google in 2014. It was created to perform image recognition tasks with high accuracy while utilizing fewer parameters and processing resources than earlier CNN systems. The utilization of a deep but narrow architecture is one of GoogleNet's primary advantages. GoogleNet employs a number of smaller filters in parallel as opposed to earlier CNN architectures, which used a huge number of filters in each layer. This reduces the amount of parameters in the network while enabling a wider receptive field. The idea of "inception modules," which are used to extract features at various scales, was also developed by GoogleNet. The usage of a "global average pooling" layer by GoogleNet, which lessens overfitting and enhances the network's generalization, is another benefit of the system. The conventional fully linked layers included in earlier CNN architectures, which are prone to overfitting, are replaced by this layer.

6. RESEARCH GAP

6.1. **Bias and fairness**: Studies have demonstrated that face recognition systems discriminate against people based on their race, gender, and age. Research is required to determine the best ways to make these systems more fair and less biased.

6.2. **Privacy and security**: Face recognition systems create privacy and security issues, especially when employed for monitoring or other forms of surveillance. How to make sure that these systems are secure and that people's privacy is respected requires research.

6.3. **Robustness and accuracy**: Face recognition systems' effectiveness can be impacted by factors including lighting, positioning, and others. Research is required to determine the best ways to make these systems more accurate and resilient, especially in real-world situations.

6.4. **Ethical considerations**: The usage and potential abuse of face recognition technologies raises ethical concerns. Research is required to examine the ethical issues related to the creation and use of these systems.

6.5. **User experience**: Some users, especially those with disabilities or those who are unfamiliar with technology, may find it difficult to use face recognition systems. To make these technologies more useable and accessible to a wider range of people, research is required on how to enhance user experience.

7. DEALING WITH ROBUSTNESS AND ACCURACY

For dealing with Accuracy issues in face recognition technology, newer models can be used that surpass the earlier models. Some of them are:

7.1. **VGGFace2**: A deep convolutional neural network model called VGGFace2 performs at the cutting edge on benchmark datasets for face recognition like LFW, YTF, and IJB-A. The deep neural network design used by the model, which has a lot of layers and parameters, enables it to recognise complex patterns and features in facial photographs.

7.2. **FaceNet**: Another deep neural network model, FaceNet, has attained cutting-edge results on benchmarks for facial recognition. A high-dimensional feature space with faces of the same identification grouped together and faces of different identities separated is learned by the model using a triplet loss function.

7.3. **DeepID**: DeepID is a family of deep neural network models that have been developed for face recognition. The models use multiple layers of convolutional neural networks (CNNs) to learn features from the face images and then combine the features using a fusion layer to produce a final representation.

8. APPLICATIONS

8.1. **Security and Surveillance**: Face recognition technology is used in security and surveillance systems to identify individuals in real-time, monitor access to secure areas, and track individuals of interest.

8.2. **Biometric Authentication**: Face recognition technology is used in biometric authentication systems for secure access control, login authentication, and other applications where secure identity verification is required.

8.3. **Law Enforcement**: Law enforcement agencies use face recognition technology to identify suspects in criminal investigations, track missing persons, and monitor public spaces.

8.4. **Healthcare**: Face recognition technology is used in healthcare for patient identification, tracking patient records, and reducing the risk of medical errors.

8.5. **Education**: Face recognition technology is used in education for attendance tracking, verifying student identities, and improving overall campus security.

8.6. **Transportation**: Face recognition technology is used in transportation for verifying the identity of passengers at airports, train stations, and other transportation hubs, reducing the risk of fraud and unauthorized access.

Fig 5. Automatic ticket gate with face recognition system in Osaka Metro Morinomiya Station

9. CHALLENGES AND LIMITATIONS

9.1. **Accuracy and Potential Bias**: One of the biggest problems with facial recognition technology is potential Bias. Face recognition technology's accuracy can be impacted by a number of variables, including lighting, image quality, and facial expressions. Face recognition software also carries the chance of bias, particularly when it comes to age, colour, and gender.

9.2. **Privacy and Ethical Issues**: Privacy and ethical issues present another difficulty for face recognition technology. The use of facial recognition data raises concerns since it can be used to follow people and even invade their privacy. Concerns exist around the data's collection, storage, and utilization.

9.3. **Computing power**: For training and processing huge amounts of data, face recognition technology needs a lot of computing power. Smaller organizations or those with few resources may find this difficult.

9.4. **Data Security**: Due to the possibility of cyberattacks or hacking attempts, there are also concerns regarding the security of facial recognition data. Concerns exist regarding the potential exploitation of facial recognition data by outside parties.

9.5. **Data protection and privacy laws**: Data protection and privacy laws, among other legal and regulatory considerations, apply to the use of facial recognition technology. These laws might differ by jurisdiction and be challenging to understand and follow.

10. EMERGING TRENDS AND INNOVATIONS

10.1. Deep Learning: Using deep learning methods, such as convolutional neural networks (CNNs), to train face recognition models is one of the most important advances in face identification technology. The accuracy of face recognition systems has been proven to be greatly improved by deep learning.

10.2. 3D Face Recognition: 3D face recognition is an emerging trend that involves using 3D models of a person's face to improve the accuracy of face recognition. This technology can capture more detailed facial features, including depth and texture, that are not captured in 2D images.

10.3. Anti-Spoofing Techniques: One of the biggest challenges of face recognition technology is spoofing attacks, where a system is tricked by a fake or manipulated image. Anti-spoofing techniques, such as liveness detection, are emerging as a way to improve the security of face recognition systems.

10.4. Edge Computing: Edge computing, where processing occurs at the edge of a network instead of a central server, is an emerging trend in face recognition technology. This technology can reduce latency and improve the speed of face recognition systems.

10.5. Hybrid Models: Hybrid face recognition models that combine multiple techniques, such as 2D and 3D recognition, are emerging as a way to improve accuracy and overcome limitations in existing face recognition systems.

10.6. Explainability: Explainable AI, or XAI, is an emerging trend that seeks to make AI models more transparent and understandable. Explainability is becoming increasingly important in face recognition technology, as it can help to address ethical and legal concerns about the use of the technology.

11. FUTURE SCOPE

11.1. Healthcare: Face recognition technology could be used in healthcare for patient identification and tracking. This could help to reduce errors and improve patient outcomes.

11.2. Transportation: Face recognition technology could be used in transportation for identity verification, such as in airports or train stations. This could help to reduce wait times and improve security.

11.3. Education: Face recognition technology could be used in education for student identification and tracking, as well as for monitoring classroom behavior.

11.4. Banking: Face recognition technology could be used in banking for identity verification and fraud prevention. This could help to improve security and reduce financial losses.

11.5. Smart Homes: Face recognition technology could be used in smart homes to personalize user experiences, such as automatically adjusting the temperature or lighting based on the user's preferences.

11.6. Entertainment: Face recognition technology could be used in entertainment for personalized experiences, such as recommending movies or music based on the user's facial expressions.

11.7. Social Media: Face recognition technology could be used in social media for tagging and identifying friends in photos, as well as for personalized content recommendations.

12. COMPARISON: Eigen Faces vs LBP vs CNN vs SVM

12.1. Eigenfaces: Eigenfaces is a linear-based algorithm that uses Principal Component Analysis (PCA) to extract features from face images. Eigenfaces is appropriate for real-time applications because of its relatively low processing complexity. Eigenfaces may not work well when there aren't enough training photos since they have trouble portraying non-linear variations in face appearance.

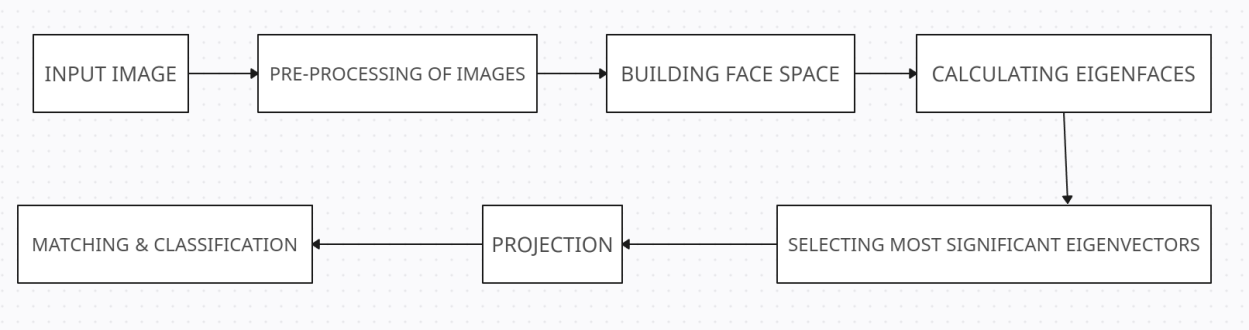

Fig 6. Eigenfaces Architecture

12.2. LBP: LBP, a texture-based technique is used to extract regional information from photographs of faces. LBP is appropriate for use in practical face recognition applications since it has been demonstrated to be resilient to changes in illumination and expression. LBP could have trouble with changes in occlusion and position.

12.3. CNN: CNN is a deep learning-based technique that uses convolutional layers and pooling layers to directly learn features from raw face photos. CNN has demonstrated cutting-edge performance on a number of face recognition criteria. Large amounts of training data and computing power may be needed for CNN.

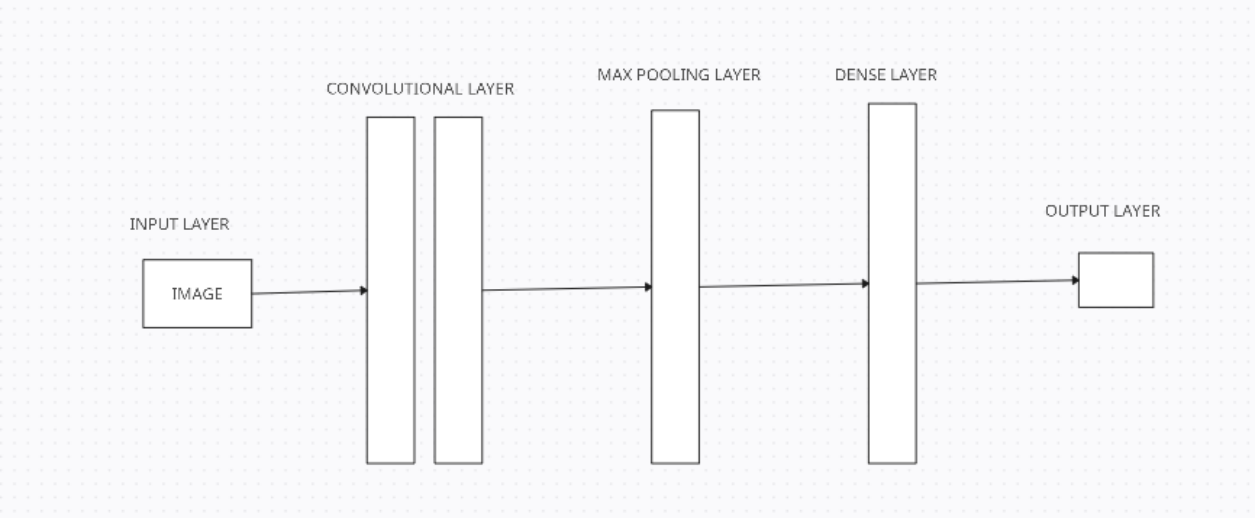

Fig 7. CNN Architecture

12.4. SVM: SVM is a feature extraction algorithm that works well with different feature extraction methods like Eigenfaces, LBP, or CNN. When used in conjunction with the right feature extraction methods, SVM has been demonstrated to achieve excellent accuracy in face recognition applications. SVM may not perform well with large datasets and can be computationally expensive.

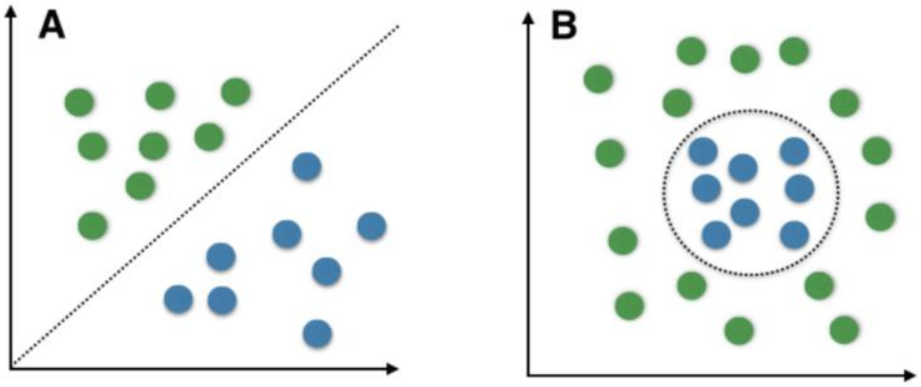

Fig 8. & 9. A) Linearly Separable Data, B) Non-Linearly Separable Data

13. CONCLUSION

This research paper studies various machine learning and deep learning models. It mainly goes through various models and compares the pros and cons of each. Each of these methods has advantages and disadvantages of its own. Although Eigen Faces is simple and effective, a large amount of training data is required. LBP is quick and efficient, but it could overlook some of a face's distinguishing characteristics. Despite being powerful and capable of learning complex properties, CNN consumes a lot of processing resources. SVM may not work well by itself, but it works well in combination with other techniques. The technique to adopt will be determined by the particular application and the resources at hand. Sometimes combining several approaches can produce greater results. Only a few of the numerous techniques, such as Eigen Faces, LBP, CNN, and SVM, have been developed for this purpose. As technology advances, we might expect to see the creation of ever-more-complex techniques that will improve the accuracy and efficiency of facial recognition systems.

14. REFERENCES

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