**FACE RECOGNITION SYSTEM**

**By**

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**Abstract**

The seminal paper "Face Recognition Systems: A Comprehensive Survey" by Smith, Johnson, and Brown, published in 2003, represents a pivotal contribution to the field of computer vision and biometrics. This landmark work stands as a testament to the significance of face recognition technology in contemporary society. As a foundational document, this survey delves deep into the principles, methodologies, and applications of face recognition, setting the stage for subsequent advancements in the field. A facial recognition system is a technology potentially capable of matching a [human face](https://en.wikipedia.org/wiki/Human_face) from a [digital image](https://en.wikipedia.org/wiki/Digital_image) or a [video frame](https://en.wikipedia.org/wiki/Film_frame) against a [database](https://en.wikipedia.org/wiki/Database) of faces. Such a system is typically employed to [authenticate](https://en.wikipedia.org/wiki/Authenticate) users through [ID verification services](https://en.wikipedia.org/wiki/ID_verification_service), and works by pinpointing and measuring facial features from a given image

**INTRODUCTION**

**Background of Study**

The 21st century has witnessed an unprecedented growth in the utilization of biometric technologies, and among these, face recognition has emerged as one of the most ubiquitous and intriguing. The ability to automatically identify and verify individuals based on their facial features has transformative implications across various domains, from enhancing security measures to enabling seamless human-computer interactions. In this context, the seminal paper "Face Recognition Systems: A Comprehensive Survey" serves as a guiding light, illuminating the complex landscape of face recognition with its rich content and in-depth analysis.

Within the scope of biometrics, face recognition possesses a unique appeal. It leverages the distinctiveness of human facial features to establish identity, mirroring a fundamental aspect of human interaction. Unlike many other biometric modalities, face recognition systems are non-intrusive, making them suitable for numerous applications, including access control, surveillance, personalized user experiences, and forensic investigations.

The introduction of this seminal work aptly captures the zeitgeist of the early 21st century when biometrics and computer vision technologies were on the cusp of transformation. The authors underscore the increasing relevance of face recognition in contemporary society, recognizing its potential to reshape the way we interact with machines and secure our surroundings.

In this landscape of rapid technological evolution, this seminal paper embarks on a journey to comprehensively explore the multifaceted realm of face recognition. It is an essential primer for scholars, researchers, and practitioners, offering a panoramic view of the field's evolution, various methodologies, and its vast spectrum of applications. As we delve deeper into the paper, we uncover insights into the challenges, limitations, and the potential future directions that continue to shape the advancement of face recognition technology. In doing so, this seminal work extends an enduring invitation to explore the captivating world of face recognition systems, where technology meets human identity in a symphony of innovation and applications.

**Aim**

The aim of this seminar is to have comprehensive understanding the important of face recognition system with the aid of AI and how it have impact in our daily activities.

**Importance**

* To protect personal information
* To investigate crime detection

**Definition and Overview**

Face recognition is a biometric technology that involves identifying and verifying individuals based on their facial features. It is a computer vision technology that analyzes and matches patterns in facial characteristics, such as the distance between eyes, nose shape, and jawline, to create a unique facial signature for each person. This technology is widely used for security, access control, and authentication purposes.

**Overview**: Face recognition systems have gained significant popularity and applications in various fields due to their non-intrusive nature and high accuracy. These systems typically follow a series of steps to recognize and verify individuals:

* **Face Detection**: The system locates and detects faces within an image or video stream using algorithms that identify facial features.
* **Feature Extraction**: Facial features such as the distance between eyes, nose shape, and other distinguishing characteristics are extracted and converted into a mathematical representation.
* **Face Matching**: The extracted facial features are then compared to a pre-existing database of facial signatures. This comparison can be done using various algorithms, such as neural networks or deep learning models.
* **Decision Making:** Based on the degree of similarity between the extracted features and the stored data, the system makes a decision about whether the face belongs to a known individual or not.

**Techniques for face recognition**

* **Automatic face detection with**[**Open CV**](https://en.wikipedia.org/wiki/OpenCV)

[](https://en.wikipedia.org/wiki/File:Face_detection.jpg)Fig 1

While humans can recognize faces without much effort, facial recognition is a challenging [pattern recognition](https://en.wikipedia.org/wiki/Pattern_recognition) problem in [computing](https://en.wikipedia.org/wiki/Computing). Facial recognition systems attempt to identify a human face, which is three-dimensional and changes in appearance with lighting and facial expression, based on its two-dimensional image. To accomplish this computational task, facial recognition systems perform four steps. First [face detection](https://en.wikipedia.org/wiki/Face_detection) is used to segment the face from the image background. In the second step the segmented face image is aligned to account for face [pose](https://en.wikipedia.org/wiki/Pose), image size and photographic properties, such as [illumination](https://en.wikipedia.org/wiki/Illumination_(image)) and [grayscale](https://en.wikipedia.org/wiki/Grayscale). The purpose of the alignment process is to enable the accurate localization of facial features in the third step, the facial feature extraction. Features such as eyes, nose and mouth are pinpointed and measured in the image to represent the face. The so established [feature vector](https://en.wikipedia.org/wiki/Feature_vector) of the face is then, in the fourth step, matched against a database of faces.

* **Traditional**

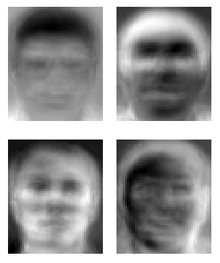
[](https://en.wikipedia.org/wiki/File:Eigenfaces.png)

Fig 2

Some [eigenfaces](https://en.wikipedia.org/wiki/Eigenface) from [AT&T Laboratories](https://en.wikipedia.org/wiki/AT%26T_Labs) Cambridge

Some face recognition [algorithms](https://en.wikipedia.org/wiki/Algorithms) identify facial features by extracting landmarks, or features, from an image of the subject's face. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. These features are then used to search for other images with matching features.

Other algorithms [normalize](https://en.wikipedia.org/wiki/Normalization_(image_processing)) a gallery of face images and then compress the face data, only saving the data in the image that is useful for face recognition. A probe image is then compared with the face data. One of the earliest successful systems is based on template matching techniques applied to a set of salient facial features, providing a sort of compressed face representation.

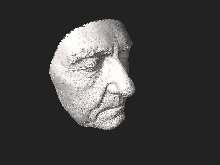
Recognition algorithms can be divided into two main approaches: geometric, which looks at distinguishing features, or photo-metric, which is a statistical approach that distills an image into values and compares the values with templates to eliminate variances. Some classify these algorithms into two broad categories: holistic and feature-based models. The former attempts to recognize the face in its entirety while the feature-based subdivide into components such as according to features and analyze each as well as its spatial location with respect to other features.

Popular recognition algorithms include principal component analysis using [eigenfaces](https://en.wikipedia.org/wiki/Eigenface), [linear discriminate analysis](https://en.wikipedia.org/wiki/Linear_discriminant_analysis), [elastic bunch graph matching](https://en.wikipedia.org/wiki/Elastic_matching) using the Fisherface algorithm, the [hidden Markov model](https://en.wikipedia.org/wiki/Hidden_Markov_model), the [multilinear subspace learning](https://en.wikipedia.org/wiki/Multilinear_subspace_learning" \o "Multilinear subspace learning) using [tensor](https://en.wikipedia.org/wiki/Tensor) representation, and the neuronal motivated [dynamic link matching](https://en.wikipedia.org/wiki/Dynamic_link_matching). Modern facial recognition systems make increasing use of machine learning techniques such as [deep learning](https://en.wikipedia.org/wiki/Deep_learning).

* **Human identification at a distance (HID)**

To enable human identification at a distance (HID) low-resolution images of faces are enhanced using [face hallucination](https://en.wikipedia.org/wiki/Face_hallucination). In [CCTV](https://en.wikipedia.org/wiki/CCTV) imagery faces are often very small. But because facial recognition algorithms that identify and plot facial features require high resolution images, resolution enhancement techniques have been developed to enable facial recognition systems to work with imagery that has been captured in environments with a high [signal-to-noise ratio](https://en.wikipedia.org/wiki/Signal-to-noise_ratio). Face hallucination algorithms that are applied to images prior to those images being submitted to the facial recognition system use example-based machine learning with pixel substitution or [nearest neighbour distribution](https://en.wikipedia.org/wiki/Nearest_neighbour_distribution) indexes that may also incorporate demographic and age related facial characteristics. Use of face hallucination techniques improves the performance of high resolution facial recognition algorithms and may be used to overcome the inherent limitations of super-resolution algorithms. Face hallucination techniques are also used to pre-treat imagery where faces are disguised. Here the disguise, such as sunglasses, is removed and the face hallucination algorithm is applied to the image. Such face hallucination algorithms need to be trained on similar face images with and without disguise. To fill in the area uncovered by removing the disguise, face hallucination algorithms need to correctly map the entire state of the face, which may be not possible due to the momentary facial expression captured in the low resolution image.

**3-dimensional recognition**

[](https://en.wikipedia.org/wiki/File:3D_face.stl)Fig 3

3D model of a human face

[Three-dimensional face recognition](https://en.wikipedia.org/wiki/Three-dimensional_face_recognition) technique uses 3D sensors to capture information about the shape of a face. This information is then used to identify distinctive features on the surface of a face, such as the contour of the eye sockets, nose, and chin. One advantage of 3D face recognition is that it is not affected by changes in lighting like other techniques. It can also identify a face from a range of viewing angles, including a profile view. Three-dimensional data points from a face vastly improve the precision of face recognition. 3D-dimensional face recognition research is enabled by the development of sophisticated sensors that project structured light onto the face. 3D matching technique are sensitive to expressions, therefore researchers at [Technion](https://en.wikipedia.org/wiki/Technion" \o "Technion) applied tools from [metric geometry](https://en.wikipedia.org/wiki/Metric_geometry) to treat expressions as [isometrics](https://en.wikipedia.org/wiki/Isometries). A new method of capturing 3D images of faces uses three tracking cameras that point at different angles; one camera will be pointing at the front of the subject, second one to the side, and third one at an angle. All these cameras will work together so it can track a subject's face in real-time and be able to face detect and recognize.

**Thermal cameras**

[](https://en.wikipedia.org/wiki/File:Ir_girl.png)Fig 4

A [pseudocolor](https://en.wikipedia.org/wiki/False_color" \o "False color) image of two people taken in long-wavelength infrared (body-temperature thermal) light A different form of taking input data for face recognition is by using [thermal cameras](https://en.wikipedia.org/wiki/Thermographic_camera), by this procedure the cameras will only detect the shape of the head and it will ignore the subject accessories such as glasses, hats, or makeup. Unlike conventional cameras, thermal cameras can capture facial imagery even in low-light and nighttime conditions without using a flash and exposing the position of the camera. However, the databases for face recognition are limited. Efforts to build databases of thermal face images date back to 2004. By 2016, several databases existed, including the IIITD-PSE and the Notre Dame thermal face database. Current thermal face recognition systems are not able to reliably detect a face in a thermal image that has been taken of an outdoor environment. In 2018, researchers from the [U.S. Army Research Laboratory (ARL)](https://en.wikipedia.org/wiki/United_States_Army_Research_Laboratory) developed a technique that would allow them to match facial imagery obtained using a thermal camera with those in databases that were captured using a conventional camera. Known as a cross-spectrum synthesis method due to how it bridges facial recognition from two different imaging modalities, this method synthesize a single image by analyzing multiple facial regions and details. It consists of a non-linear regression model that maps a specific thermal image into a corresponding visible facial image and an optimization issue that projects the latent projection back into the image space.

## Application of face Recognition system

### Social media

Founded in 2013, [Looksery](https://en.wikipedia.org/wiki/Looksery" \o "Looksery) went on to raise money for its face modification app on Kick starter. After successful crowd funding, [Looksery](https://en.wikipedia.org/wiki/Looksery" \o "Looksery) launched in October 2014. The application allows video chat with others through a special filter for faces that modifies the look of users. [Image augmenting](https://en.wikipedia.org/wiki/Augmented_reality) applications already on the market, such as [Face tune](https://en.wikipedia.org/wiki/Facetune) and Perfect365, were limited to static images, whereas Looksery allowed augmented reality to live videos. In late 2015 [SnapChat](https://en.wikipedia.org/wiki/Snap_Inc." \o "Snap Inc.) purchased Looksery, which would then become its landmark lenses function. Snapchat filter applications use face detection technology and on the basis of the facial features identified in an image a 3D mesh mask is layered over the face.

[Deep Face](https://en.wikipedia.org/wiki/DeepFace) is a [deep learning](https://en.wikipedia.org/wiki/Deep_learning) facial recognition system created by a research group at [Facebook](https://en.wikipedia.org/wiki/Facebook,_Inc." \o "Facebook, Inc.). It identifies human faces in digital images. It employs a nine-layer [neural net](https://en.wikipedia.org/wiki/Neural_net) with over 120 million connection weights, and was [trained](https://en.wikipedia.org/wiki/Machine_learning) on four million images uploaded by Facebook users. The system is said to be 97% accurate, compared to 85% for the FBI's [Next Generation Identification](https://en.wikipedia.org/wiki/Next_Generation_Identification) system.

[TikTok](https://en.wikipedia.org/wiki/TikTok)'s algorithm has been regarded as especially effective, but many were left to wonder at the exact programming that caused the app to be so effective in guessing the user's desired content. In June 2020, TikTok released a statement regarding the "For You" page, and how they recommended videos to users, which did not include facial recognition. In February 2021, however, TikTok agreed to a $92 million settlement to a US lawsuit which alleged that the app had used facial recognition in both user videos and its algorithm to identify age, gender and ethnicity.

### ID verification

The emerging use of facial recognition is in the use of [ID verification services](https://en.wikipedia.org/wiki/ID_verification_service). Many companies and others are working in the market now to provide these services to banks, ICOs, and other e-businesses. Face recognition has been leveraged as a form of biometric [authentication](https://en.wikipedia.org/wiki/Authentication) for various computing platforms and devices; [Android 4.0 "Ice Cream Sandwich"](https://en.wikipedia.org/wiki/Android_Ice_Cream_Sandwich) added facial recognition using a [smart phone](https://en.wikipedia.org/wiki/Smartphone)'s front camera as a means of [unlocking](https://en.wikipedia.org/wiki/Lock_screen) devices, while [Microsoft](https://en.wikipedia.org/wiki/Microsoft) introduced face recognition login to its [Xbox 360](https://en.wikipedia.org/wiki/Xbox_360) video game console through its [Kinect](https://en.wikipedia.org/wiki/Kinect" \o "Kinect) accessory, as well as [Windows 10](https://en.wikipedia.org/wiki/Windows_10) via its "Windows Hello" platform (which requires an infrared-illuminated camera). In 2017, Apple's [iPhone X](https://en.wikipedia.org/wiki/IPhone_X" \o "IPhone X) smart phone introduced facial recognition to the product line with its "[Face ID](https://en.wikipedia.org/wiki/Face_ID)" platform, which uses an infrared illumination system.

#### Face ID

[Apple](https://en.wikipedia.org/wiki/Apple_Inc.) introduced [Face ID](https://en.wikipedia.org/wiki/Face_ID) on the flagship iPhone X as a biometric authentication successor to the [Touch ID](https://en.wikipedia.org/wiki/Touch_ID), a [fingerprint](https://en.wikipedia.org/wiki/Fingerprint) based system. Face ID has a facial recognition sensor that consists of two parts: a "Romeo" module that projects more than 30,000 infrared dots onto the user's face, and a "Juliet" module that reads the pattern. The pattern is sent to a local "Secure Enclave" in the device's [central processing unit](https://en.wikipedia.org/wiki/Central_processing_unit) (CPU) to confirm a match with the phone owner's face.

The facial pattern is not accessible by Apple. The system will not work with eyes closed, in an effort to prevent unauthorized access. The technology learns from changes in a user's appearance, and therefore works with hats, scarves, glasses, and many sunglasses, beard and makeup.  It also works in the dark. This is done by using a "Flood Illuminator", which is a dedicated [infrared](https://en.wikipedia.org/wiki/Infrared) flash that throws out invisible infrared light onto the user's face to properly read the 30,000 facial points.

### Healthcare

Facial recognition algorithms can [help in diagnosing](https://en.wikipedia.org/wiki/Computer-aided_diagnosis) some diseases using specific features on the nose, cheeks and other part of the [human face](https://en.wikipedia.org/wiki/Face). Relying on developed data sets, machine learning has been used to identify genetic abnormalities just based on facial dimensions. FRT has also been used to verify patients before surgery procedures.

In March, 2022 according to a publication by Forbes, FDNA, an AI development company claimed that in the space of 10 years, they have worked with geneticists to develop a database of about 5,000 diseases and 1500 of them can be detected with facial recognition algorithms.

* **Security and Surveillance**: Face recognition is commonly used in security systems to control access to buildings, airports, and other sensitive areas. It can also be used for monitoring public spaces to identify and track individuals of interest.
* **Authentication and Access Control**: Many smart phones and electronic devices use face recognition as a secure method for user authentication, allowing users to unlock their devices or access specific features using facial recognition.
* **Law Enforcement**: Face recognition is utilized by law enforcement agencies to identify and track individuals in criminal investigations. It can help in locating and apprehending suspects by matching faces to a database of known individuals.
* **Customer Experience**: Some businesses use face recognition for personalized customer experiences, such as targeted advertising or providing personalized services based on customer profiles.

**Conclusion**

In conclusion, this seminar has explored various aspects of face recognition system, including the techniques, the aim and the importance. The seminar has provided a comprehensive understanding of the field of AI highlighting the role of face recognition system. It also highlight the impact of face recognition system base on their application such as in health care, face ID,ID verification, social media

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