IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# Introduction to Facial Recognition

**Samarth Roy Chowdhury**
Student at *NMIMS Mukesh Patel School of Technology Management and Engineering*
Mumbai, India

**Rish Sadh**
Student at *NMIMS Mukesh Patel School of Technology Management and Engineering*
Mumbai, India

**Pia Samant**
Student at *NMIMS Mukesh Patel School of Technology Management and Engineering*
Mumbai, India

**Jesleena Gonsalves**
Assistant Professor in Department of Computer Engineering at *NMIMS Mukesh Patel School of Technology Management and Engineering*
Mumbai, India

*Abstract*— This research paper investigates the intricacies of facial recognition technology, crucial in the realms of security systems and surveillance. The human face, a unique identifier conveying information, poses challenges in computer analysis due to the disjunction between our three-dimensional world and predominantly two-dimensional visual sensors. The burgeoning field of artificial intelligence has witnessed the development of diverse facial recognition algorithms, each navigating distinct strengths and weaknesses throughout the detection, feature extraction, and identification processes.

In the detection phase, annotation methods such as bounding boxes and semantic segmentation contribute to dataset creation for training convolutional neural networks. Machine learning, with its supervised, unsupervised, and reinforcement learning paradigms, plays a pivotal role in training models to adeptly detect faces. Feature extraction, a critical step in pattern recognition, explores the roles of machine learning, neural networks, and specific face recognition algorithms in identifying common features within datasets. The research underscores the transformative potential of facial recognition technology, envisioning a future where its continuous evolution shapes industries and daily life, unlocking new frontiers in the visual domain.

**Keywords**—Computer graphics, Artificial intelligence, Image recognition, Face recognition.

## I. Introduction

The human face is a structure with many complex angles and unique features that can convey a lot of information about the owner of the face, including expression, feeling, facial features, and a sense of identity. Human Faces always play vital parts in applications such as security systems and surveillance to identify criminal activities and perpetrators.

The intricacies of facial features are dynamic and change and evolve over time . Attention to and focus on these changes can easily identify a person. Hence, the idea of interpreting and emulating this skill is instinctive in and intrinsic to human beings can be very enticing.

Since our world is in three dimensions but our visual sensors and camera technology usually provide only two-dimensional images , it increases the difficulty for computer to analyse an object in three dimensions. However artificial intelligences are developing at a unmatched pace and Multiple facial recognition algorithms have been developed , each with its own strengths and weaknesses.

Facial recognition is an ever-enhancing process, that has three major steps detection, feature extraction and identification. [1] [2] [3]

## II. Literature Review

Feature extraction involves capturing the significant shape details within a pattern, facilitating the classification task through a systematic approach. It serves as a specialized form of dimensionality reduction in pattern recognition and image processing. The primary objective is to distill the most pertinent information from the original data, presenting it in a reduced-dimensional space. Typically conducted post-preprocessing in character recognition systems, feature extraction plays a crucial role in the broader pattern recognition process, which entails correctly categorizing an input pattern among possible output classes. This recognition process is broadly segmented into two key stages: feature selection and classification. [11][22]

In image processing, a myriad of algorithms is employed to manipulate and analyze images. These algorithms serve diverse purposes, ranging from enhancing image contrast (Histogram Equalization) and reducing noise (Median Filter) to detecting edges (Sobel Operator, Canny Edge Detector) and identifying shapes (Hough Transform). Clustering algorithms like K-Means facilitate image segmentation, while dimensionality reduction methods such as Principal Component Analysis (PCA) extract essential features. Morphological operations modify the structure of shapes in an image, and blob detection identifies regions with specific characteristics. Deep learning techniques, including Convolutional Neural Networks (CNNs) and Generative Adversarial Networks (GANs), have gained prominence in tasks such as classification, object detection, and image generation. Each algorithm caters to specific image processing needs, offering solutions for diverse challenges and applications.[2][3]

## III. Detection

### A. Annotation

Image annotation is the process of marking out the object in different images, to create data sets. Image datasets are often used for training a computer vision application's deep learning model. This is usually a convolutional neural network. This process extracts features from images. In case of face recognition, it marks out the faces. Most commonly used image annotation methods:

- Bounding Box
- Semantic Segmentation
- Polygonal Segmentation
- Line Annotation
- 3D Cuboids
- Landmark Annotation

[4][5][6][7]

### B. Training

Machine learning involves equipping machines with the ability to learn and improve over time using a given dataset. Through this process, AI models gain the ability to make predictions, recognize patterns and understand complex data. This transformation of data is what makes AI models so revolutionary.

Types of model learning:

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

In terms of facial recognition, a dataset of a large number of marked faces are used so that the AI model learns to detect a face and the different points in a face. [8][9]

### C. Inferencing

Inference is the process of running live data through a trained AI model to make a prediction or solve a task. Training and inference can be thought of as the difference between learning and putting what you learned into practice.

How fast an AI model runs depends on the stack. Improvements made at each layer: hardware, software, and middleware — can speed up inferencing on their own and together. Here the model is tested in situations to check whether the model can defect faces or not. [10]

## IV. Feature Exrtaction

### A. Role of ML

Feature extraction is an important step for patter recognition and data mining. In this step the model uses the dataset to find common features or parts using certain rules and algorithms. The model may or may not have find many features and not all can be used for classification. It was found that focusing on a smaller number of common features leads to better and more efficient results. [11]

### B. Neural Network

A neural network is a method of artificial intelligence that a computer uses to learn like a human. It is a layered structure that tries to replicate the human brain. The multilevel interconnected network allows the model to learn like a human. It helps the computer make intelligent decisions supported by a human. In the case of facial recognition, it allows the model to use the different algorithms to find common features in the faces in the data set. [12][13][14]

### C. Face Recognition Algorithm

Face recognition is the process of authenticating users through their facial attributes. There are four main categories of algorithms based on the design of the human face:

- Appearance based: It classifies the face as dimensional vectors.
- Model based: It uses shapes and texture of the face to distinguish between the features of the face.
- Template based: It uses the geometric relationships between the features of the face and the.

[15] [18]

### D. Reference Dataset

The reference dataset is the final data, which the main program uses to compare with customers data. Different amount of reference data is considered depending on the main situation. Two of the main situations are:

- Where two face are directly compared
- Where one face is compared to a pre-stored face
- Where one face is compared to a multitude of pre-stored faces. [16]

## V. Identification

### A. Matching

Matching is the process where the features on one face is compared directly to the pre-stored features of a face. For example, the face recognition used in our phones uses the matching method. Here the person who tries to unlock the phone has the features of their face compared to the pre-stored face of the original owner of the phone. [17]

### B. Searching

Searching is the process where the features of the person is compared to a collection of pre-stored faces. Here the different algorithm uses different searching methods to find the correct face in the collection. Then the program uses algorithm of matching to compare the features to the list. Some common searching methods are linear, binary and tree searching. [21]

### C. Percentage Comparison

When working with digitally tracked facial features every image will have unique conditions, like color, exposure, angle, glare, etc. When the program compares faces it will never truly be a perfect match, here the algorithm gives a percentage of confidence for each comparison.

## VI. ALGORITHMS

In this section the paper goes over some of the most used algorithms that are used by facial recognition models.

### A. Haar Model & Euclidean Distance

The Haar cascade algorithm is an object detection algorithm that searches images for trained objects. It can also be used to detect various objects in a single instance. This algorithm uses "cascading windows" and tries to compute features in every window to check if the object that is being searched for. IT is fast and works in real time but is not very accurate compared to modern object detection techniques. In face recognition, it breaks the face's features into different sections.

In mathematical terms, the Euclidean distance algorithm is used to find the distance between two points in a plane. For facial recognition, the formula is applied to the distances between the sections created by the Harr Cascade model. The distance between the points is recorded and stored. When a face is taken as input, the distance between the features is calculated and then matched with the prestored value. [17][18]

$$d(x,y)=\sqrt{\sum_{i=1}^{n}(x_i-y_i)^2}$$

### B. Arcface & Cosine Similarity

Arcface uses face embedding to extract the features of a face. The neural network gives output as vectors that represent some of the most common features. Then by using multiple images, a collection of vectors is created. Then this collection is converted to a vector space.

Then cosine similarity formula is used to find the distance between two vectors from the face, which is taken as input. Then the cosine distance is compared to other vectors in the vector space. Finally, this distance is what is used to match the face with prestored distance to verify the person. [19]

$$d(x,y)=-\frac{x\cdot y}{\|x\|\|y\|}=-\frac{\sum_{i=1}^{n}x_i y_i}{\sqrt{\sum_{i=1}^{n}x_i^2\,\sum_{i=1}^{n}y_i^2}}$$

## CONCLUSION

Image processing stands at the forefront of technological innovation, revolutionizing how we interact with visual information. From enhancing the clarity of photos to enabling advanced facial recognition, the possibilities are vast. As we navigate this dynamic field, the continuous evolution of image processing holds immense potential for shaping the future of various industries and our daily lives. Embracing these advancements opens doors to new horizons and possibilities, where the visual world becomes not just a canvas but a realm of endless opportunities for exploration and discovery.

## REFERENCES


[1] K. Teoh, R. Ismail, S. Naziri, R. Hussin, M. Isa, and M. Basir, "Face Recognition and Identification using Deep Learning Approach," Journal of Physics: Conference Series, vol. 1755, no. 1, p. 012006, Feb. 2021, doi: https://doi.org/10.1088/1742-6596/1755/1/012006.

[2] S. Singh and J. Graceline, "Face Recognition System." Available: https://www.ijert.org/research/face-recognition-system-IJERTV8IS050150.pdf

[3] S. M. Bah and F. Ming, "An improved face recognition algorithm and its application in attendance management system," Array, vol. 5, p. 100014, Mar. 2020, doi: https://doi.org/10.1016/j.array.2019.100014.

[4] "Essential guide to face recognition: How it works | SuperAnnotate," www.superannotate.com. https://www.superannotate.com/blog/guide-to-face-recognition#how-face-recognition-works (accessed Dec. 29, 2023).

[5] G. Wei and I. K. Sethi, "Face detection for image annotation," Pattern Recognition Letters, vol. 20, no. 11–13, pp. 1313–1321, Nov. 1999, doi: https://doi.org/10.1016/s0167-8655(99)00100-2.

[6] "What is Image Annotation in Deep Learning?," kili-website. https://kili-technology.com/data-labeling/computer-vision/image-annotation/different-image-annotation-types#51 (accessed Dec. 29, 2023).

[7] A. Nithya and K. Haridas, "An Overview on Facial Image Annotation," International Journal of Innovative Research in Computer and Communication Engineering, vol. 2, no. 7, pp. 5158–5163, Jan. 2014.

[8] S. Hashmi, "Face Detection in Extreme Conditions: A Machine-learning Approach." Available: https://arxiv.org/ftp/arxiv/papers/2201/2201.06220.pdf

[9] erika, "How the training of the AI models works - The Data Scientist," Aug. 16, 2023. https://thedatascientist.com/how-the-training-of-the-ai-models-works/#:~:text=It%20involves%20equipping%20machines%20with

[10] "What is AI inferencing?," IBM Research Blog, Feb. 09, 2021. https://research.ibm.com/blog/AI-inference-explained

[11] E. Bagherian and R. W. O. K. Rahmat, "Facial feature extraction for face recognition: a review," IEEE Xplore, Aug. 01, 2008. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4631649 (accessed Nov. 06, 2022).

[12] D. Dwivedi, "Face Recognition for Beginners," Towards Data Science, Apr. 28, 2018. https://towardsdatascience.com/face-recognition-for-beginners-a7a9bd5eb5c2

[13] H. A. Rowley, S. Baluja, and T. Kanade, "Neural network-based face detection," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 20, no. 1, pp. 23–38, 1998, doi: https://doi.org/10.1109/34.655647.

[14] AWS, "What is a neural network? AI and ML guide - AWS," Amazon Web Services, Inc., 2023. https://aws.amazon.com/what-is/neural-network/

[15] S. Garg, "Face recognition using Artificial Intelligence," GeeksforGeeks, Nov. 25, 2020. https://www.geeksforgeeks.org/face-recognition-using-artificial-intelligence/

[16] valentina.zezelj@beta.visagetechnologies.com, "Pros and cons of facial recognition," Visage Technologies, Aug. 09, 2023. https://visagetechnologies.com/benefits-of-face-recognition/

[17] H. Wu, Y. Cao, H. Wei, and Z. Tian, "Face Recognition Based on Haar Like and Euclidean Distance," Journal of Physics: Conference Series, vol. 1813, no. 1, p. 012036, Feb. 2021, doi: https://doi.org/10.1088/1742-6596/1813/1/012036.

[18] "Object Detection Using Haar Cascade: OpenCV," *Analytics Vidhya*, Apr. 01, 2022. ttps://www.analyticsvidhya.com/blog/2022/04/object-detection-using-haar-cascade-opencv/#:~:text=Haar%20cascade%20is%20an%20algorithm

[19] "Face Recognition," *Auriga IT*. https://aurigait.com/blog/face-recognition/#:~:text=The%20distance%20between%20faces%20is%20calculated%20using%20cosine%20distance.&text=Cosine%20similarity%20measures%20the%20similarity (accessed Jan. 06, 2024).

[20] "University Network & Information Center: Online Apps," online.bamu.ac.in. http://www.bamu.ac.in/Department_of_Computer_Science/Effect%20of%20Distance%20Measures%20on%20the%20Performance%20of%20Face%20Recognition%20using%20Principal%20Component%20Analysis_1.pdf (accessed Jan. 06, 2024).

[21] Pooja and M. Dagar, "FACE RECOGNITION USING MAHALANOBIS DISTANCE IN MATLAB," International Journal For Technological Research In Engineering, vol. 5, no. 8, pp. 2347–4718, 2018, Accessed: Jan. 06, 2024. [Online]. Available: https://ijtre.com/wp-content/uploads/2021/10/2018050826.pdf

[22] G. Gupta, "IEEE-A Detailed Review of Feature Extraction in Image Processing Systems.pdf," www.academia.edu, Available: https://www.academia.edu/32268188/IEEE_A_Detailed_Review_of_Feature_Extraction_in_Image_Processing_Systems_pdf