Face recognition using Artificial Intelligence

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Abstract-Face recognition has over time proven to be the least intrusive and fastest form of biometric verification. Facial Recognition is a category of biometric software that maps an individual's facial features and stores the data as a face print. The software uses deep learning algorithms to compare a live captured image to the stored face print to verify one's identity. Image processing and machine learning are the backbones of this technology. Face recognition has received substantial attention from researchers due to human activities found in various applications of security like an airport, criminal detection, face tracking, forensic, etc. Compared to other biometric traits like palm print, iris, fingerprint, etc., face biometrics can be non-intrusive.

They can be taken even without the user's knowledge and further can be used for security-based applications like criminal detection, face tracking, airport security, and forensic surveillance systems. This paper mainly focuses on Face recognition involving capturing face images from a video or a surveillance camera. They are compared with the stored database. Face recognition involves training known images, classify them with known classes, and then they are stored in the database. When a test image is given to the system it is classified and compared with the stored database.

I. Introduction-

Image Processing and Machine learning

Image processing by computers involves the process of Computer Vision. It deals with the high-level understanding of digital images or videos. The requirement is to automate tasks that the human visual systems can do. So, a computer should be able to recognize objects such as that of a face of a human being or a lamppost or even a statue.

a) ***Image reading***

The computer reads any image as a range of values between 0 and 255. For any color image, there are 3 primary colors – Red, green, and blue. A matrix is formed for every primary color and later these matrices combine to provide a Pixel value for the individual R, G, B colors. Each element of the matrices provide data about the intensity of the brightness of the pixel.

b) ***OpenCV*** is a Python library that is designed to solve computer vision problems. OpenCV was originally developed in 1999 by Intel but later supported by Willow Garage. OpenCV supports a variety of programming languages such as C++, Python, Java, etc. Support for multiple platforms including Windows, Linux, and macOS. OpenCV Python is a wrapper class for the original C++ library to be used with Python. Using this, all of the OpenCV array structures get converted to/from NumPy arrays. This makes it easier to integrate it

with other libraries that use NumPy. For example, libraries such as SciPy and Matplotlib.

Machine learning

Every Machine Learning algorithm takes a dataset as input and learns from the data it basically means to learn the algorithm from the provided input and output as data. It identifies the patterns in the data and provides the desired algorithm. For instance, to identify whose face is present in a given image, multiple things can be looked at as a pattern:

- Height/width of the face.
- Height and width may not be reliable since the image could be rescaled to a smaller face or grid. However, even after rescaling, what remains unchanged are the ratios – the ratio of the height of the face to the width of the face won't change.
- Color of the face.
- Width of other parts of the face like lips, nose, etc.

There is a pattern involved – different faces have different dimensions like the ones above. Similar faces have similar dimensions. Machine Learning algorithms only understand numbers so it is quite challenging. This numerical representation of a "face" (or an element in the training set) is termed as a feature vector. A feature vector comprises of various numbers in a specific order.

As a simple example, we can map a "face" into a feature vector which can comprise various features like:

- Height of face (cm)
- Width of the face (cm)
- Average color of face (R, G, B)
- Width of lips (cm)
- Height of nose (cm)

Essentially, given an image, we can convert them into a feature vector like:

Height of face (cm) Width of the face (cm) Average color of face (RGB) Width of lips (cm) Height of nose (cm)

23.1 15.8 (255, 224, 189) 5.2 4.4

So, the image is now a vector that could be represented as (23.1, 15.8, 255, 224, 189, 5.2, 4.4). There could be countless other features that could be derived from the image,, for instance, hair color, facial hair, spectacles, etc.

Machine Learning does two major functions in face recognition technology. These are given below:

1. Deriving the feature vector: it is difficult to manually list down all of the features because there are just so many. A Machine Learning algorithm can intelligently label out many of such features. For instance, a complex feature could be the ratio of the height of the nose and width of the forehead.
2. Matching algorithms: Once the feature vectors have been obtained, a Machine Learning algorithm needs to match a new image with the set of feature vectors present in the corpus.
3. Face Recognition Operations

II. Face Recognition Operations

The technology system may vary when it comes to facial recognition. Different software applies different methods and means to achieve face recognition. The stepwise method is as follows:

- ***Face Detection:*** To begin with, the camera will detect and recognize a face. The face can be best detected when the person is looking directly at the camera as it makes it easy for facial recognition. With the advancements in the technology, this is improved where the face can be detected with slight variation in their posture of face facing to the camera.
- ***Face Analysis:*** Then the photo of the face is captured and analyzed. Most facial recognition relies on 2D images rather than 3D because it is more convenient to match to the database. Facial recognition software will analyze the distance between your eyes or the shape of your cheekbones.
- ***Image to Data Conversion:*** Now it is converted to a mathematical formula and these facial features become numbers. This numerical code is known a face print. The way every person has a unique fingerprint, in the same way, they have unique face print.
- ***Match Finding:*** Then the code is compared against a database of other face prints. This database has photos with identification that can be compared. The technology then identifies a match for your exact features in the provided database. It returns with the match and attached information such as name and addresses or it depends on the information saved in the database of an individual.

III. Face Recognition Softwares

Many renowned companies are constantly innovating and improvising to develop face recognition software that is foolproof and dependable. Some prominent software is being discussed below:

a. Deep Vision AI

Deep Vision AI is a front runner company excelling in facial recognition software. The company owns the proprietorship of advanced computer vision technology that can understand images and videos automatically. It then turns the visual content into real-time analytics and provides very valuable insights.

Deep Vision AI provides a plug and plays platform to its users worldwide. The users are given real-time alerts and faster response based upon the analysis of camera streams through various AI-based modules. The product offers a highly accurate rate of identification of individuals on a watch list by continuous monitoring of target zones. The software is highly flexible that it can be connected to any existing camera system or can be deployed through the cloud.

At present, Deep Vision AI offers the best performance solution in the market supporting real-time processing at +15 streams per GPU.

Business intelligence gathering is helped by providing real-time data of customers, their frequency of visits, or enhancement of security and safety. Further, the output from the software can provide attributes like count, age, gender, etc that can enhance the understanding of consumer behaviour, changing preferences, shifts with time, and

conditions that can guide future marketing efforts and strategies. The users also combine the face recognition capabilities with other AI-based features of Deep Vision AI like vehicle recognition to get more correlated data of the consumers.

The company complies with the international data protection laws and applies significant measures for a transparent and secure process of the data generated by its customers. Data privacy and ethics are taken care of.

The potential markets include cities, public venues, public transportation, educational institutes, large retailers, etc. Deep Vision AI is a certified partner for NVIDIA's Metropolis, Dell Digital Cities, Amazon AWS, Microsoft, Red Hat, and others.

b. SenseTime

- SenseTime is a leading platform developer that has dedicated efforts to create solutions using the innovations in AI and big data analysis. The technology offered by SenseTime is multifunctional. The aspects of this technology are expanding and include the capabilities of facial recognition, image recognition, intelligent video analytics, autonomous driving, and medical image recognition. SenseTime software includes different subparts namely, SensePortrait-S, SensePortrait-D, and SenseFace.
- SensePortrait-S is a Static Face Recognition Server. It includes the functionality of face detection from an image source, extraction of features, extraction, and analysis of attributes, and target retrieval from a vast facial image database
- SensePortrait D is a Dynamic Face Recognition Server. The capabilities included are face detection, tracking of a face, extraction of features, and comparison and analysis of data from data in multiple surveillance video streams.
- SenseFace is a Face Recognition Surveillance Platform. This utility is a Face Recognition technology that uses a deep learning algorithm. SenseFace is very efficient in integrated solutions to intelligent video analysis. It can be extensively used for target surveillance, analysis of the trajectory of a person, management of population and the associated data analysis, etc
- SenseTime has provided its services to many companies and government agencies including Honda, Qualcomm, China Mobile, UnionPay, Huawei, Xiaomi, OPPO, Vivo, and Weibo.

c. Amazon Rekognition

Amazon provides a cloud-based software solution Amazon Rekognition is a service computer vision platform. This solution allows an easy method to add image and video analysis to various applications. It uses a highly scalable and proven deep learning technology. The user is not required to have any machine learning expertise to use this software. The platform can be utilized to identify objects, text, people, activities, and scenes in images and videos. It can also detect any inappropriate content. The user gets a highly accurate facial analysis and facial search capabilities. Hence, the software can be easily used for verification, counting of people, and public safety by detection, analysis, and comparison of faces.

Organizations can use Amazon Rekognition Custom Labels to generate data about specific objects and scenes available in images according to their business needs. For example, a model may be easily built to classify specific machine parts on the assembly

line or to detect unhealthy plants. The user simply provides the images of objects or scenes he wants to identify, and the service handles the rest.

IV. Utilization of Face Recognition

While facial recognition may seem futuristic, it's currently being used in a variety of ways. Here are some surprising applications of this technology.

- ***Genetic Disorder Identification:***
  There are healthcare apps such as Face2Gene and software like Deep Gestalt that uses facial recognition to detect a genetic disorder. This face is then analyzed and matched with the existing database of disorders.
- ***Airline Industry:***
  Some airlines use facial recognition to identify passengers. This face scanner would help saving time and to prevent the hassle of keeping track of a ticket.
- ***Hospital Security:***
  Facial recognition can be used in hospitals to keep a record of the patients that is far better than keeping records and finding their names, address. It would be easy for the staff to use this app and recognize a patient and get its details within seconds. Secondly, can be used for security purpose where it can detect if the person is genuine or not or is it a patient.
- ***Detection of emotions and sentiments:***
  Real-time emotion detection is yet another valuable application of face recognition in healthcare. It can be used to detect emotions which patients exhibit during their stay in the hospital and analyze the data to determine how they are feeling. The results of the analysis may help to identify if patients need more attention in case they're in pain or sad.

V. Problems and Challenges

The face recognition technology is facing several challenges. The common problems and challenges that a face recognition system can have while detecting and recognizing faces are discussed in the following paragraphs.

- ***Pose:*** A Face Recognition System can tolerate cases with small rotation angles, but it becomes difficult to detect if the angle would be large and if the database does not contain all the angles of the face then it can impose a problem.
- ***Expressions:*** Because of the emotions, human mood varies and results in different expressions. With these facial expressions, the machine could make mistakes to find the correct person identity.
- ***Aging:*** *W*ith time and age face changes it is unique and does not remain rigid due to which it may be difficult to identify a person who is now 60 years old.
- ***Occlusion:*** Occlusion means blockage. This is due to the presence of various occluding objects such as glasses, beard, moustache, etc. on the face, and when an image is captured, the face lacks some parts. Such a problem can severely affect the classification process of the recognition system.

- ***Illumination:*** Illumination means light variations. Illumination changes can vary the overall magnitude of light intensity reflected from an object, as well as the pattern of shading and shadows visible in an image. The problem of face recognition over changes in illumination is widely recognized to be difficult for humans and algorithms. The difficulties posed by illumination condition is a challenge for automatic face recognition systems.
- ***Identify similar faces:*** Different persons may have a similar appearance that sometimes makes it impossible to distinguish.

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