Face Recognition using Deep Learning Algorithms

Introduction to Deep Learning

Deep learning is a type of artificial intelligence that follows the principle of the human brain for information gathering and decision-making. Therefore, it is also called a deep neural network [1]. In the world of accuracy, deep learning algorithms have gained recognition accuracy at the highest level. Deep learning has recently become so accurate that it outperforms human intelligence for image and object detection [2]. Most deep learning algorithms use the neural network architecture comprising numerous hidden layers in the network. While the traditional neural network only has 3-4 hidden layers, whereas deep networks may have 100 hidden layers. One of the most well-known deep neural networks is recognized as Convolution Neural Network (CNN). A CNN model can learn the features from input data using a 2D convolutional layer. The CNN architecture makes it well suited to work on 2D data like images. For CNN to work, the user did not require to extract the images features instead, the CNN itself extracts them from images. Also, the model does not require any training for feature extraction. These feature extractions make the CNN model highly suitable for computer vision tasks like object detection and fake image detection [3].

Face Recognition:

An image is worth a thousand words is the statement by Henrik Ibsen that indicates the importance of an image in our lives. It also explains the impact of an image that can deliver a complex message with one visual rather than having a lengthy verbal description [4]. In the era of technology, the face image has been widely used for authentication, called face recognition or image recognition. So, face recognition is the method of identifying a person's identity using their face [5]. For this purpose, a face recognition system can identify the people in photos and videos. Facial recognition can be used for automated security, access control, education, retails, healthcare, law enforcement, fraud detection and healthcare [6].

Several deep learning models have been used for face detection and recognition, including the DeepFace, VGG-face, FaceNet and DeepID [7].

VGG-Face [8]**:**

The VGG, for Visual Geometry Group, is one of the most commonly used face recognition models. The model was based on a deep neural network called as VGGNet. It got the researcher's attention during the ImageNet challenge while achieving the top position in the computation. The researcher at University of Oxford designed the model. The model has attained the accuracy of 97.2% on the LFW dataset.

FaceNet [9]**:**

The model FaceNet was designed by Google researchers and is known as the state-of-art face detection and recognition model. It was designed using deep learning and can be used for face recognition and verification. The model has reached an accuracy of 99.60% of the LFW dataset.

DeepFace [10]**:**

The deepFace model was designed by Facebook researchers and was trained on the dataset of four million images. The model was built on a deep neural network with a structure of nine layers. The Facebook model has achieved an accuracy of 97.35 of the LFW dataset.

Applications of Deep Learning Algorithms in Face Recognition:

Face recognition has gained great importance recently because of its application in different technology domains. Therefore, it is considered a hot area for researchers. Different researchers have proposed many applications of different deep learning models. This section will review some of the most recent deep learning algorithms applied for face recognition.

CNN-Based Facial Recognition System:

As discussed above, CNN has been recommended to solve various computer vision problems. Its convolution and pooling layers have been very successful in hidden feature extraction.

Chen et al. [1] proposed a lightweight, CNN-based, real-time face recognition system. The model was designed to achieve high accuracy with low computational cost and is considered suitable for low-resource embedded systems. The model applied the two-step feature extract method. The first step extracts low-level features from images while applying the convolutional and pooling layers. The second step uses these features for face classification using a fully connected layer. The model has achieved very good accuracy while applied on a standard face recognition benchmark dataset, and it also achieved the lowest computational cost making it suitable for low resources devices.

Said et al. [2] presented a face recognition system applying a CNN network. The system has three stages: face detection, feature extraction and classification. The system has achieved an accuracy of 89.99% while tested on the LFW dataset having 13000 face images of different individuals.

Hernandez et al. [3] proposed a quality assessment system called Faceqnet using deep learning models. The proposed system used a CNN-based algorithm for face detection and recognition. The model was tested on LFW and YTF datasets and the model was able to gain an accuracy of 92.24% and 91.54% for LFW and YTF, individually.

Limitations of CNN-based Face Recognition System:

Although the CNN model has achieved great accuracy for application in face recognition systems, there are still several limitations of the algorithms that need to be considered while applying it for recognition.

- First, a CNN needs a large quantity of labeled data for training to provide better results. But obtaining such data requires resources especially for real-time face detection [14].

- Secondly, the CNN-based models are very sensitive to variation, pose, expression and illumination. Therefore, the CNN models are unsuitable for a real-me face detection system where pose and vision could be problematic [15].

GAN-Based Face Recognition System:

The GAN, or generative adversarial network, is the latest deep learning model used for data generation similar to a given dataset. GANs are very commonly used for computer vision problems explicitly where the least amount of training data is available. The algorithm can generate new data using the least training data [16]. Despite being a data generator, the GAN algorithms have been used for face recognition. Here we will review some of the applications of GAN-based face recognition systems [17].

Luo et al. [4] presented a GAN-based model for generating deformation invariant face images for the accuracy improvement of the recognition system. The FA-GAN model generated a sequence of face images along various deformation, illumination, and rotation conditions for augmentation along the original dataset. The system was tested on different datasets, including LFW, YTF and Multi-PIE datasets, along with various pose and illumination changes. Still, it has achieved an accuracy of 99.1% for LFW and 98.3% for the YTF dataset.

Zhang et al. [5] proposed a GAN-based face recognition system for thermal to visible images to solve the problem of thermal visible face images. The model, named TV-GAN, generated visible images from thermal images and enhanced the face recognition system's accuracy. The TV-GAN model was applied to LFW, YTF, and CASIA- webFace datasets, and the model has gained accuracy of 92.6%, 89.6% and 98.2% for the LFW, YTF and CASIA-WebFace images datasets. One of the major problems with the model is the condition for a large number of visible face images for training.

Limitations of GAN-Based Recognition System:

As we have seen the advantages and accuracy of GAN-based recognition systems, but there are several limitations of these algorithms that are discussed here:

- The GAN-based system is sensitive to training data that was applied to generate synthetic face images. But if the training data applied was biased or tempered, it could lead to inaccurate and unrealistic images.
- Also, the GAN-based face recognition systems are computationally expensive as they require large computations for synthetic image generation. Therefore, these systems do not apply to small and medium computational devices [20].

Industrial Applications of Deep Learning Algorithms:

We have seen that deep learning algorithms have been applied in computer vision, robotics, natural language processing, and healthcare. Here are some of the applications of deep learning in the respective field.

Virtual Assistants:

A virtual assistant is a cloud-based application with the feature to understand voice commands and complete user tasks. Amazon, Google Assistant, Siri, and Alexa, are examples of virtual assistants. These virtual assistant devices use deep learning algorithms to understand natural language and respond accurately to user queries. Deep learning can be used in virtual assistants to provide the facility of speech recognition, Natural language Processing, Sentiment Analysis, and Image and Object Recognition [21].

Healthcare:

Deep learning has been applied in the health sector to solve different problems. It is commonly used for medical imaging, drug discovery, health monitoring, medical research and personalized medicine. These deep leering models are also very effective for disease prediction using CT scans and radio images of patients [22].

Fake News Detection:

Fake News refers to misleading information presented as if it is real News. Fake News could be in the form of articles, images, videos and social media posts. Fake News has been a problem in the era of social media and online news networks. Deep learning has been applied for fake news detection. Deep learning algorithms can be used for social media analysis, fake image and video detection on social media, NLP and sentiment analysis [23].

Along with these applications, deep learning algorithms have been used in chatbots, recommendation systems, robotics, advertising, NLP, self-driving cars, and fraud detection.

Future of Deep Learning in Face Recognition System:

As discussed above, the limitations of deep learning models for face recognition systems include data hungriness, model bias to input, computational cost, and data breaches. Here are some solutions that could help solve these problems of deep learning models for the application in face recognition systems.

- Applying data augmentation, transfer learning, active learning, and semi-supervised learning could solve the problems of data hungriness of deep learning algorithms.
- By adversarial training, regularization and applying fairness constraints on input data can solve the problem of biases from input data.
- The computational problems of deep learning models can be solved by applying model optimization, hardware optimization and model pruning.

While discussing the problems and their solution, it is time to discuss the future trends of the face recognition system. As it is obvious that the future of face recognition technology is very bright, let's discuss some future products of face recognition systems.

Emotion Detection:

Emotion detection and recognition is a promising field and has been a potential research area. Emotion recognition can be very helpful for advertising, customer service and the healthcare system.

3D Face Recognition:

As we know, face recognition systems currently rely on 2D images captured from a single point of view, which is a problem for the accuracy of deep learning models. 3D recognition systems that apply 3D information for feature extraction can be more accurate and robust.

Multi-Domain Recognition:

Multi-domain or cross-domain recognition involves facial recognition across different domains. For example, a person face can be recognized from an image and a video at the same time. These applications can be very useful for surveillance and security.

In short, face recognition system using deep learning algorithms has been very popular because of their accuracy and performance. This system applied CNN, GNN, GAN, and autoencoder for feature extraction from input facial images. These features help the models to identify and authenticate an individual. Still, these algorithms have several challenges and limitations for face recognition systems, including data biases, availability, security and privacy concerns. Keeping in mind these problems are opportunities for new research in the area. It is very important to note that the face recognition system should be applied responsibly. Because they are potential threats to personal privacy if not handled with caution. Overall, the rapid developments in deep learning algorithms have increased the availability of high-quality data that will improve the performance of face recognition systems in future.

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