Building Face Ageing Model Using Face Synthesis

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Abstract:- Advancements in face synthesis technology have enabled innovative methods for modeling facial aging. This research paper focuses primarily on creating a robust face aging model using deep learning and Generative Adversarial Networks (GANs), trained on a diverse dataset of facial images. The proposed approach captures both global features and local textures to produce realistic age-progressed images while preserving the subject's identity. This paper also examines face synthesis techniques, with specific emphasis for the various practical usage of GANs. The key objective of our project is to upgrade both the discriminator and the generator parts of GANs to generate more realistic, age-progressed face images. We evaluated the model using quantitative metrics and qualitative assessments, demonstrating its effectiveness. Additionally, we address ethical considerations, proposing guidelines for responsible use. Our study offers a novel framework with significant applications in security, forensics, and entertainment, and suggests future research directions to improve accuracy and ethical standards.

Keywords:- *Generative Adversarial Networks (GANs), Convolutional Neural Networks (CNNs), Generator, Discriminator, IP-CGAN.*

I. INTRODUCTION

To try to smooth the puzzles of time's transit engraved on human figures, the marriage of artificial intelligence and photographic synthesis has appeared as a transformative force. This aging phenomenon of face, has basically natural, enchanted researchers and expounders across disciplines, from forensic science to entertainment, outstanding its profound implications and diverse applications. The face aging field of face synthesis has adapted an experienced a prototype change with the development of deep learning approaches, primarily Generative Adversarial Networks (GANs), which have generated in previously unattainable levels of naturalism and consistency in age progression.

Previously, age cycle methods mostly depended on human adaptations or fundamental programming that couldn't adequately behold the exclusiveness of facial aging. However, the introduction of GANs signaled a revolution in the field of generating various models. The primary concept behind how GANs function is that ,how a discriminator network tries to differentiate between the actual and artificial samples, while a generator network make efforts achieving aim to create realistic data samples.

Both the networks grind their skills through an iterative adversarial procedure, giving results in the creation of lifelike images. After merging computer vision, machine learning, and image processing, the main purpose of GANs for addressing aging synthesis tells how to transform the several fields and fundamentally transform the understanding of aging dynamics.

This article addresses unsolved issues by upgrading the generation procedure as a discriminator's performance and providing a thorough overview of the most recent developments in face aging synthesis using GANs. In this we researched the underneath concepts behind GANs and how they are used for generating realistic facial images. We then examined a wide range of methods which focused at negotiating with certain situations which are associated with face aging, such as time progression reliability, authenticity, and personality preservation.

Further , we have explained how evaluation demands and standard datasets portray a vital role while assessing the effectiveness of face aging models and clarify the subtle aspects of sensation stature, age advancement commitment, and identity preservation. We have also looked at the revolutionary potential of GAN-based face aging synthesis in a variety of operations, from digital amusement platforms to fingerprint verification systems, furthermore in the technical components.

However regardless of the clear future, there are the meaningful ethical questions and society implications to ponder. The putting together of intentionally aged images opens up questions about permission, privacy, and the prospective abuse of synthetic data. Therefore , we enhance the value of responsible invention and ethical governance in exploiting the energize of GANs for face aging synthesis.

Finally, the combination of GANs with face development synthesis signals the start of a new era of the technological advancement by giving never-before-seen circumstances to solve the problems of time as well as convert how we relate to aging. While we control the future ethical and societal issues that we will work is to fully discover the possible of this creative upgraded by serious research and worthy implementation.

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A. Problem Statement

Traditional approaches of face synthesis often have failed to produce the realistic aged images with the preservation of the identity of the input images. They also lack the ability to balance the identity preservation and age progression which result in generating the images that lack fidelity and are inconsistent. Therefore, it was needed to develop such approach that can produce high fidelity images and also maintaining the characteristics of the input images. Hence, we have implemented Identity Preserved CGAN approach that is capable of fulfilling the objective. This paper provide a robust solution for producing the aged faces while preserving the identity and improving the generator and discrimination performance.

B. Objective

To develop a face aging application using face synthesis techniques which helps to generate aged face images using the young inputs and also increasing the performance of the generator and discriminator. The objective includes building a robust model based on Generative Adversarial Networks in order to synthesize a realistic image. Moreover, the paper also seeks at enhancing the generator and discriminator's performance. To increase the potency of the model both qualitative and quantitative analysis will be conducted.

II. RELATED WORK

Some various approaches for face aging are outlined in Pranoto, H et al [1]. This paper described Conventional Approach, Deep Generative Model for Face Aging Approach and Generative Adversarial Networks Approach. Conventional approach includes Model-Based Approach, Prototype Approach and Reconstruction-Base Approach. Deep Generative Model for Face Aging Approach includes Temporal Restricted Boltzmann Machine-Based Model (TRBM), Recurrent Neural Network-Based Model and Generative Adversarial Networks Approach. Generative Adversarial Networks Approach includes Translation-Based Approach, Triple-GAN, Child Face Age-Progression VIA Deep Feature Aging, Sequence Based Approach, Subject Dependent Deep Aging Path (SDAP) Model and Conditional-Based Approach.

The use of Conditional GAN (CGAN) can be seen in Antipov, G et al [2], where extra details such as age labels are provided to both the generator and discriminator. This addition allows for more accurate control over the process of aging, ensuring that the images generated display age-appropriate characteristics while maintaining identity features.

A combined approach for face age progression using Attention-GAN and SRGAN is presented in Neha Sharma et al [3]. Attention-GANs utilize attention mechanisms to selectively attend to facial regions that are more prone to age-related changes, such as wrinkles, fine lines, and changes in skin texture. By emphasizing these regions during the generation process, Attention-GANs can produce age progressed images that exhibit more realistic aging effects while preserving the identity of the individual. In SRGAN (Super-Resolution Generative Adversarial Network), the generator network aspires to depict images of low resolution into the images with the high-resolutions, whereas the discriminator learns to differentiate between real images and the images generated by the generator.

We observed that in Kaneko et al [4], it provides a thorough examination of Generative Adversarial Networks (GANs), while illuminating the diverse applications and principles across multiple domains. This paper examines the detailed underlying techniques of GANs, where a generator network and a discriminator network engage in competition, with the generator striving to produce outputs of heightened realism. Furthermore, this paper also highlighted the applications of GANs, spanning image generation, data augmentation, image-to-image translation, and so forth. Y. Singh et al [5] described various activation functions for classification problems and suggested some more suitable activation function for specification problems.

In paper by Sharma et al [6] a fresh approach to face aging synthesis has been presented. They focused on feature fusion techniques to enhance the realism and accuracy of age-progressed facial images. Their approach offers a more extensive and refined depiction of facial aging dynamics, by integrating feature-level information from diverse sources, including facial landmarks, texture patterns, and framework characteristics. They utilized Generative Adversarial Networks (GANs) for the advancement of cutting-edge face age progression. The study deals with the growing significance of facial age progression techniques in many applications, such as law enforcement, entertainment, and forensics, highlighting the need for realistic and high-quality transformations. This research adds to the ongoing advancement of facial image processing techniques, offering promising paths for applications requiring age progression and super-resolution capabilities.

Z. Zhang et al [7] introduced a sophisticated approach to face aging utilizing an innovative structure termed A3GAN. The proposed A3GAN model adequately captures and preserves distinctive facial features while synthesizing realistic aged faces by integrating a feature-aware attentive mechanism within a Generative Adversarial Network (GAN) architecture. This feature-awareness enables the network to concentrate on particular facial attributes, enhancing the accuracy of age progression results.

X. Tang et al [8] demonstrated an alternative framework for training generative models, Generative Adversarial Nets. The conditional version of generative adversarial nets are proposed, which can be developed by feeding the data. Their model consisted of two adversarial models: a generative model which holds the data distribution, and a discriminative model that evaluates the probability that a sample came from the training data. They also illustrated how this model can be used for learning a multi-modal model, and provide early demonstrations of an application to image categorization.

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Conditional GANs (CGANs) take advance information for image generation and construct the generated images with suitable target age. Paper [9] presented an Identity-Preserved Conditional Generative Adversarial Networks (IPCGANs) for face aging, motivated by the accomplishments of CGANs.

Generative Adversarial Networks (GANs) have emerged as an influential framework for face aging models because of their potential to produce a realistic as well as superior top notch images. GANs consist of two main components: a generator and a discriminator. The generator which is frequently depicted as deep neural network takes input of random noises and converts them into texts or images while the discriminator distinguishes between real/actual and generated images.

III. METHODOLOGY

In recent, face ageing application has gained interests because of its wide range applications in fields of entertainment, forensics etc.. However, the obstacle lie in the generation of the aged faces from the young face inputs. Therefore, Generative Adversarial Networks, a face synthesis techniques provide a promising solution in this direction by producing a high quality images. It consists of 2 neural network which helps in one aims at generating the realistic images whereas other differentiate between the real and the fake images.

A methodological approach to building face aging applications using face synthesis is presented in this paper having main and specific focus on improving the performance of the discriminator and generator components of the adversarial network. The primary objective was to develop a robust and efficient system which is capable of generating realistic aged faces images from young face inputs. This is achieved through machine learning, Python programming language, Convolutional Neural Networks (CNNs), and image processing techniques.

The qualitative data that we utilized was collected from Kaggle, a widely-used platform for sharing datasets and conducting data-driven research. The dataset collected had been pre-processed so as to ensure the consistency and quality in the inputted data. Facial alignment to normalize face orientations, resize images to a standard resolution had been performed and then pixel values are normalized to a common scale. Moreover, we had employed data augmentation techniques I.e. rotation, flipping, and scaling so as to increase variability of the dataset and also improving the robustness of the trained model.

An iterative training process had been adopted for the GAN, where both the generator and discriminator networks were trained simultaneously. During training, appropriate loss functions are defined including adversarial loss, feature perceptual loss, and matching loss for guiding the optimization of the discriminator and generator. Transfer learning techniques might also be utilized, initializing the GAN with pre-trained models to expedite convergence. The training processes were carried out using TensorFlow which facilitates efficient computation and scalability.

For evaluating the performance of the trained GAN, quantitative and qualitative metrics were done. Quantitatively, the generator and discriminator both are analysed on the basis of loss weights which carry out the training process. Different metrics are included such as generative adversarial loss, feature matching loss, and age classification accuracy to assess the quality and variety of the generated aged faces. Qualitatively, visual inspections and human evaluation studies were conducted so as to compare the generated images with ground truth aged faces from the dataset collected from Kaggle, ensuring the visual realism and perceptual quality of the result.

The proposed methodology was implemented using Python programming language, through TensorFlow for model training and evaluation. Extensive experimentation was conducted for exploring several hyperparameters, network architectures, and training strategies. For feature extraction and representation learning, CNNs were employed, while machine learning techniques were utilized for data analysis and model optimization.

Python programming which is a versatile programming language, is used to carry out the implementation process because of its readability and rich libraries. CNN plays a vital role the Identity preserved CGANs framework for both the generator and the discriminator. CNNs abilities helps to identify and extract common image patterns vital for generating the images along with identity preservation. Image processing techniques help in pre-processing the training data and face detection, alignment etc. are done to normalize the input images. An open-source ML platform i.e. TensorFlow is used to train and deploy the network because of its robustness in handling the large datasets.

The output of the experiments demonstrated the potencial of the proposed methodology in improving the performance of the discriminator and generator in the face aging applications. We have presented the quantitative metrics and qualitative assessments, showing the quality and realism of the generated aged faces. We have compared the performance and discussed the implications of our findings of our approach with existing techniques, highlighting the advantages or limitations.

An important factor of building face aging applications using face synthesis was the selection of an appropriate GAN architecture and hence evaluated several architectures including IPCGAN, DCGAN, StyleGAN, and Pro-GAN, considering the factors such as computational efficiency and image quality. Based on the evaluation, we chose a GAN architecture that had strike a balance between these factors and was well-suited for the tasks of face synthesis. The generator and discriminator networks were designed using CNN architectures which is optimized for image generation and discrimination. TensorFlow was also employed because

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of its efficiency and flexibility in implementing deep learning models.

In the paper, we have shown a methodological approach for building face aging applications using the approach GANs architecture such as IPCGAN and CGAN which produce the aged face images from the young inputs provided and also having a special focus on improving the performance of the discriminator and generator using GANs.

A. Network Architecture

In this paper, we have implemented the IP-CGAN i.e. Identity Preserved Conditional GAN which is used because of its dual objective. Firstly, it generates realistic aged images from the young face inputs and also preserve the identity of the inputted image.

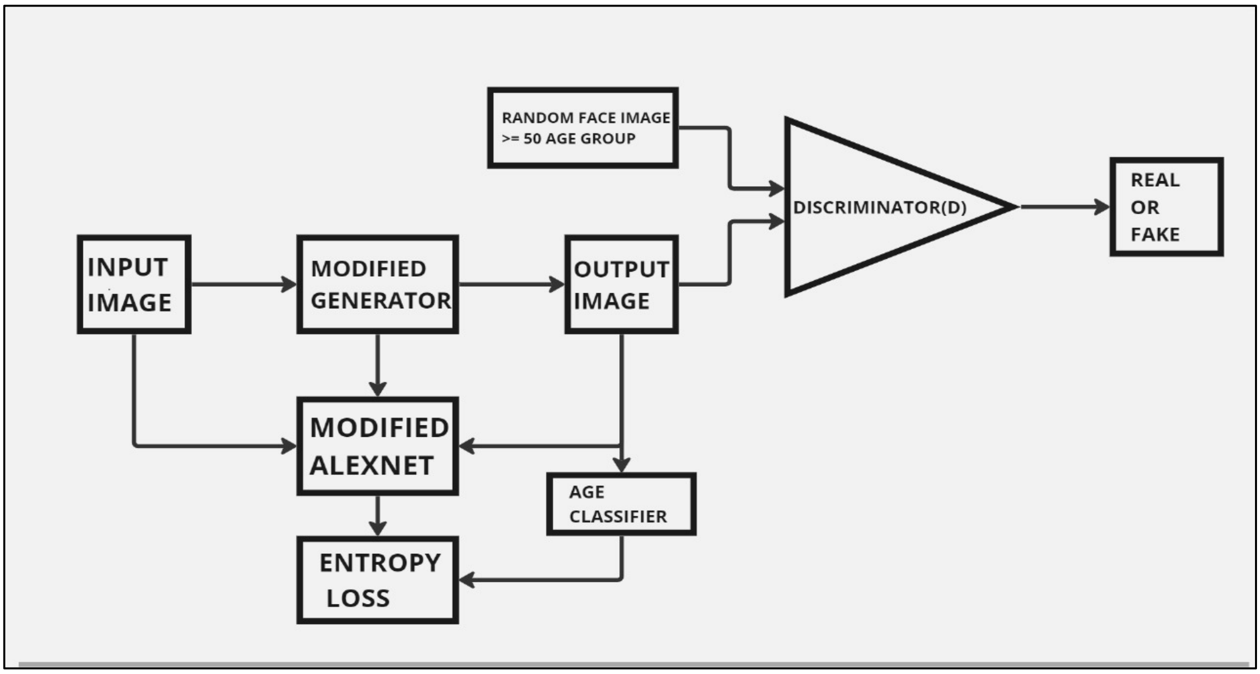

Fig. 1. Network Architecture

In IP-GAN generator comprises of several convolutional layers, un-sampling layers and residual blocks. The layers are designed to transform the input face images into the aged face images and also preserving the identity features. Figure 1 shows the network architecture of the model. It leverages various activation functions and regularization techniques in order to make smooth and natural age progression. On the other hand, discriminator network in IP-CGAN differentiate between real and fake images while at the same time preserve the identity information. Like generator, it also employs a series of convolutional layer, down sampling layers, and fully connected layers in order to effectively differentiate between real and synthesized images.

The research focused on contributing to advancing the fields of face aging technology, offering a robust and efficient solution so as to generate a realistic aged faces from young face inputs. We anticipated that our proposed methodology would inspire further research and development in the following area and opening new avenues for applications in various sectors.

IV. IMPLEMENTATION

A. Experimental Setup

For the paper, we have explored face aging effects using Identity-Preserved Conditional Generative Adversarial Networks as presented in paper[10]. We have setup the experimental environment with the different libraries and dependencies. TensorFlow-gpu of version 1.4.1 is utilized for the GPU resources. SciPy, OpenCV-python and NumPy are the core dependencies used for addressing the scientific computing and image processing needs. CUDA toolkit is also installed in order to ensure the compatibility and optimal performance with Tensor Flow GPU.

B. Dataset

In this paper we have chosen Cross Age Celebrity Dataset from Kaggle for the purpose of training and evaluation. The dataset holds more than 1 lakh images of approximately 2000 celebrities with age between 15 to 65. All the images in the dataset have large variation in pose, illumination, expressions and their styles. The dataset is partitioned into two parts: training and test data where training data is categorized into groups according to ages.

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C. Model Evaluation

We have implemented the IPCGAN i.e. Identity Preserved Conditional Generative Adversarial Network approach in our paper. In the paper, we have first compared the different GANs methods with our method which are all build on conditional GANs and are quite similar to our method. We have used TensorFlow- GPU, scipy and numpy libraries for the implementation of our method. We started training the data from the scratch where we first downloaded the pre-trained model, including AlexNet and an age classification model where age classifier is finetuned on celebrity training dataset with 200000 steps and the whole training process complete in about 5 lakh steps. Additionally, we employed specific hyperparameters such as age loss weight, feature loss weight to balance the identity preservation and the aging effect. We have chosen conv5 feature layer for the feature extraction so as to optimize face ageing translation.

D. Loss Function

We have utilized the loss functions for the training of generator and discriminator of the IP-CGANs. The adversarial loss function encourages the generator for producing more realistic images in order to fool the discriminator and the feature matching loss ensures that the images generated matched the real images in order to preserve the identity of the different age groups. These loss functions are important to maintain the balance between the uniqueness of the identity characteristics and age progression and thereby increasing the performance of the network.

E. Improvement

To enhance the performance of the generator and the discriminator within IP-CGANs, AlexNet, a pre trained model and age classification models are used for the purpose of quick convergence and better generalization through the transfer learning. Hyperparameter tuning such as adversarial loss and the feature matching loss helps ensures a balance between the networks. Feature extraction layer such as conv5 ensures the identity preservation along with the introduction of the age-specific features.

V. RESULT AND DISCUSSION

In our paper, we have compared the effectiveness of the Identity Preserved Conditional Generative Adversarial Networks with many other approaches.

Fig. 2. Some Results of IPCGANs

Figure 2 depicts the aging effects of the model. The results showed the higher fidelity image while maintaining the uniqueness of the identity feature and also achieved a natural ageing effect. IPCGANs achieves an exceptional accuracy of approx. 96 % for the face verification and better image quality by 71% as compared with the other methods. The result produced with our approach shows it has excellently preserved the unique features of the input images and yield the age-related characteristics.

Quantitative evaluation shows that the approached used in the paper has been able to perform better in terms of preserving the uniqueness of the identity of all the age groups. Through the model, it can be seen that the mean squared error of the input and the generated image is also reduced with the IP-CGANs method. The mean square error score of approx. 0.012 and the structural similarity index of 0.85 shows high fidelity and similarity with the target. This shows the ability of the model in preserving the integrity of the image identity throughout the ageing process. Quantitative assessment also shows that proposed approach has demonstrated higher accuracy in comparison with the baseline.

Qualitative analysis shows that while doing the visual examination of the result, close resemblance of the generated aged faces found with the targeted aged faces which shows the preservation of the identity of the input face. IP-CGANs has various applications in multiple domains such as digital entertainment, security, and helping find missing persons. This identity-preserved aging model holds promise for improving the precision of age-progressed images in these highly sensitive domains. It is also important to acknowledge the constraints in our study. First of all our results depends upon the quality and diversity of the training dataset utilized. Moreover, the computational resources, necessary for the training and inference, might bring various restrictions and demerits to the feasibility of our approach when used with real time scenarios.

VI. CONCLUSION

This paper has proposed improvement to both the network components of the generative adversarial network i.e. generator and discriminator. Through the current development in this field, a comprehensive overview has been offered in the face ageing using GANs approach. IP-CGAN, a GANs methodology is used in the paper with its dual objective of both enhancing the performance and the fidelity of the generated aged images from the young inputs along with the identity preservation makes it a valuable tool for the accurate representation of the implemented approach of age progression. Moreover, the paper stresses on the necessity of ethical scrutiny which are responsible for the development of the face synthesis technology by emphasising on the importance of potential biases and moral implications investigation. Altogether, the approach presented in the paper pave a way for continuing progress in the face synthesis application across various fields such as healthcare, forensics, entertainment industry etc.

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