Review on 3d Face Reconstruction from A Single 2d Image

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ABSTRACT

With many uses in fields including facial identification, animation, and virtual reality, 3D face reconstruction is a difficult computer vision problem. Using a mix of feature extraction, depth estimation, and 3D morphable model fitting, we describe a revolutionary technique in this research for reconstructing a 3D face from a single 2D image. In the first step of our method, the input image is pre-processed to align the face and eliminate any occlusions. We then use a scale-invariant feature transform to extract discrete facial characteristics from the pre-processed image (SIFT). Using methods like form from shading and multivariate Gaussian distribution (MVGD), these features are used to determine the depth of the image. The generated depth map is then utilized to fit the input image to a 3D morph able model (3DMM). The main applications are virtual try-on, gaming, medical imaging, virtual reality, advertising and marketing, medical applications, security and, and social media.

Keywords: Animation, Depth estimation, computer vision, Scale-invariant feature transforms, Multivariate Gaussian distribution.

INTRODUCTION

In the fields of computer vision and image processing, 3D face reconstruction has become increasingly important due to its potential applications in various sectors, such as security, robotics, medicine, gaming, advertising, and social media. Compared to 2D graphics, 3D imaging offers the potential to go beyond the limitations of 2D graphics. Researchers studying image processing have shown great interest in 3D images because of their significant contributions to a variety of sectors. The 3D reconstruction of human faces has particular significance due to its implications for face recognition technology.

Face recognition is considered the most challenging use of 3D reconstruction because of the difficulty in matching faces accurately and efficiently in 3D space. Our suggested approach offers a solution that requires only one image to effectively rebuild a 3D image, making it computationally efficient and practical for actual systems. The approach's efficiency can be demonstrated by comparing the root mean square error (RMS) with that of current state-of-the-art methods. Our approach also extracts distinctive SIFT features in addition to facial data, which produces an effective 3D reconstruction. SIFT features (scale-invariant feature transform) are image features Page | 1that can be extracted from an image regardless of the scale, orientation, or lighting conditions. By using SIFT features along with facial data; we can create more accurate 3D models of a person's face.

The 3D model of a person's face has various applications, including virtual try-on, gaming, medicalimaging, virtual reality, advertising, marketing, social media, and security. Virtual try-on technology uses the3D model of a person's face to virtually try on different hairstyles, glasses, makeup, and even clothes to see how they would look without actually trying them on. This technology is particularly useful for the fashion industry, as it allows customers to try on different clothing items without physically trying them on. In the gaming industry, the 3D model of a person's face can be used to create realistic characters with facial expressions that respond to the player's actions. This technology is already being used in games such as NBA 2K and FIFA to create more realistic avatars.

In medical imaging, 3D models of a person's face can be used to create customized prosthetics and orthotics or to simulate surgical procedures before they are performed. This technology can also be used to create realistic models of the human skull for surgical planning and education. In the field of virtual reality, the 3D model of a person's face can be used to create a realistic avatar for virtual reality environments, allowing people to interact with others in a virtual

space. This technology is already being used in social VR platforms such as Oculus Rooms and Face book Spaces.
In the advertising and marketing industry, the 3D model of a person's face can be used to create personalized advertising campaigns that target specific individuals based on their facial features and expressions. This technology can also be used to create realistic CGI models for film and television. Medical applications can also benefit from this technology by using it to create 3D models of patients' faces for surgical planning, prosthetic design, and other medical applications. Lastly, the ability to create 3D models of people's faces can be useful in facial recognition and security applications, and in creating 3D avatars for social media platforms, allowing users to express themselves in a more realistic and engaging way. This technology has the potential to revolutionize the way we interact with each other in virtual spaces, and to improve the accuracy and efficiency of many industries.

LITERATURE SURVEY

***Feng Liu, Qijun Zhao, Xiaoming Liu*, *Dan Zeng* [1]**, proposed system presents a joint face alignment and 3D face reconstruction method to simultaneously address the issues for 2D face photographs of arbitrary poses and expressions by examining the high association between 2D landmarks and 3D shapes. This approach employs two cascaded regressors sequentially and alternatively, one for updating 2D landmarks and the other for 3D shape, based on a summing model of 3D faces and cascaded regression in 2D and 3D shape spaces. A 3D-to-2D mapping matrix, which is changed after each iteration to improve the placement and visibility of 2D landmarks, connects the 3D shape and the landmarks. The suggested method, in contrast to existing approaches, can fully automatically produce both pose- and expression-normalized and expressive 3D faces as well as localize both visible and undetectable 2D landmarks. We develop a technique to improve face identification accuracy across poses and expressionsusing the

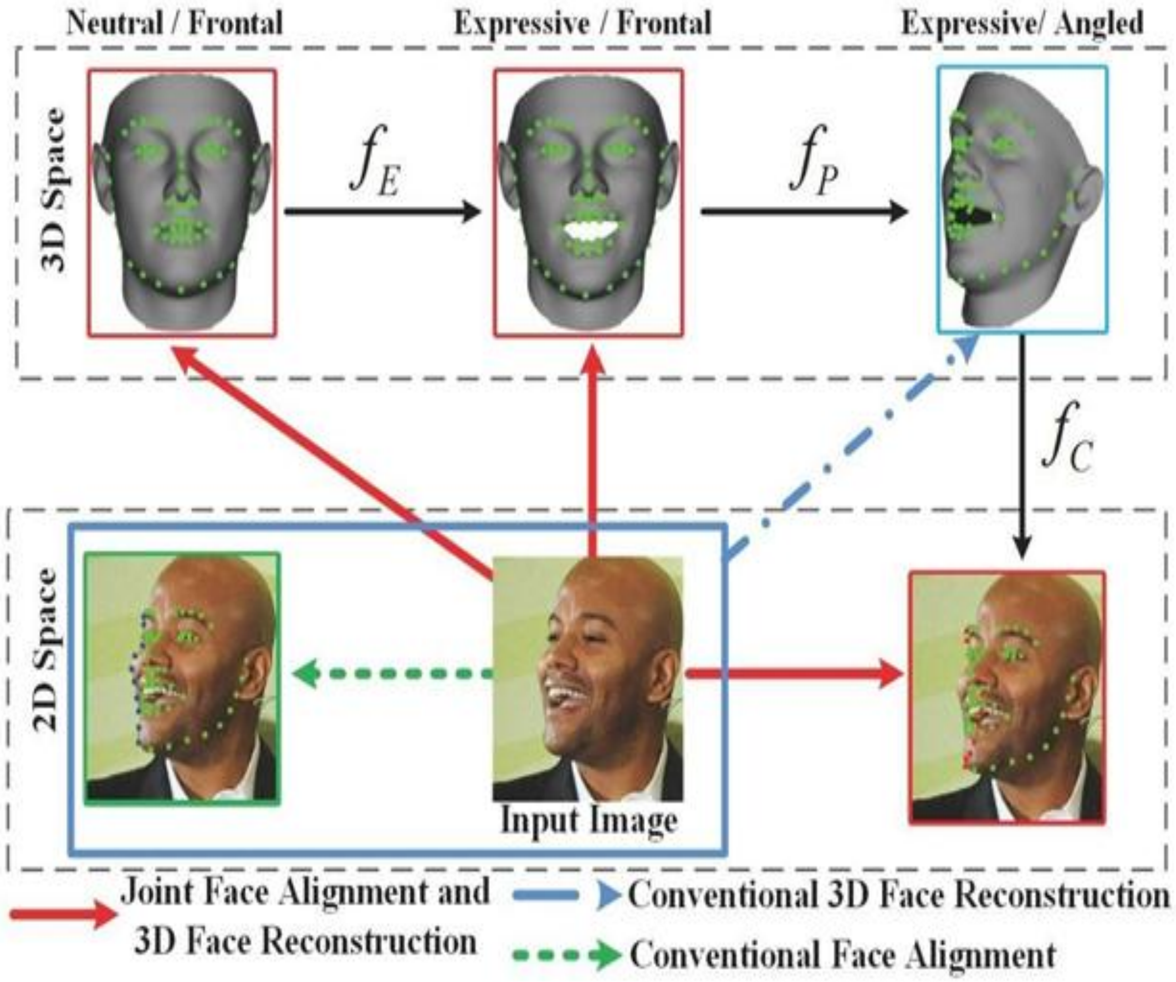

Fig. 1: 3D Faces As Well As Localize both Visible and Undetectable 2D Landmarks

This study presents and assesses implementations of the suggested strategy that are both linear and nonlinear. **Xiaoguang Tu, Jian Zhao, Akshaya Balamurugan [2],** the task of reconstructing a 3D face from a single image is crucial in many multimedia applications. Recent studies often learn a CNN-based 3D face model that reconstructs a 3D face from 2D photos using the coefficients of a 3D Morphable Model (3DMM).

Fig. 2: Dense Face Alignment (Odd Rows) and 3D Face Reconstruction (Even Rows)

However, the performance of these methods is significantly constrained by the lack of training data with 3Dannotations. We propose a novel 2D-Assisted Learning (2DAL) approach to effectively use "in the wild" 2Dface images with noisy landmark information to significantly enhance 3D face model learning in order to address this issue.

Luo Jiang, Juyong Zhang, Bailin Deng, and Hao Li,and Ligang Liu[3],creating a 3D face from a single image is a well-known and difficult problem with numerous applications. We create a novel technique for reconstructing 3D faces from unconstrained 2D images using a coarse-to-fine optimization strategy, which isinspired by recent works in face animation from RGB-D or monocular video inputs.

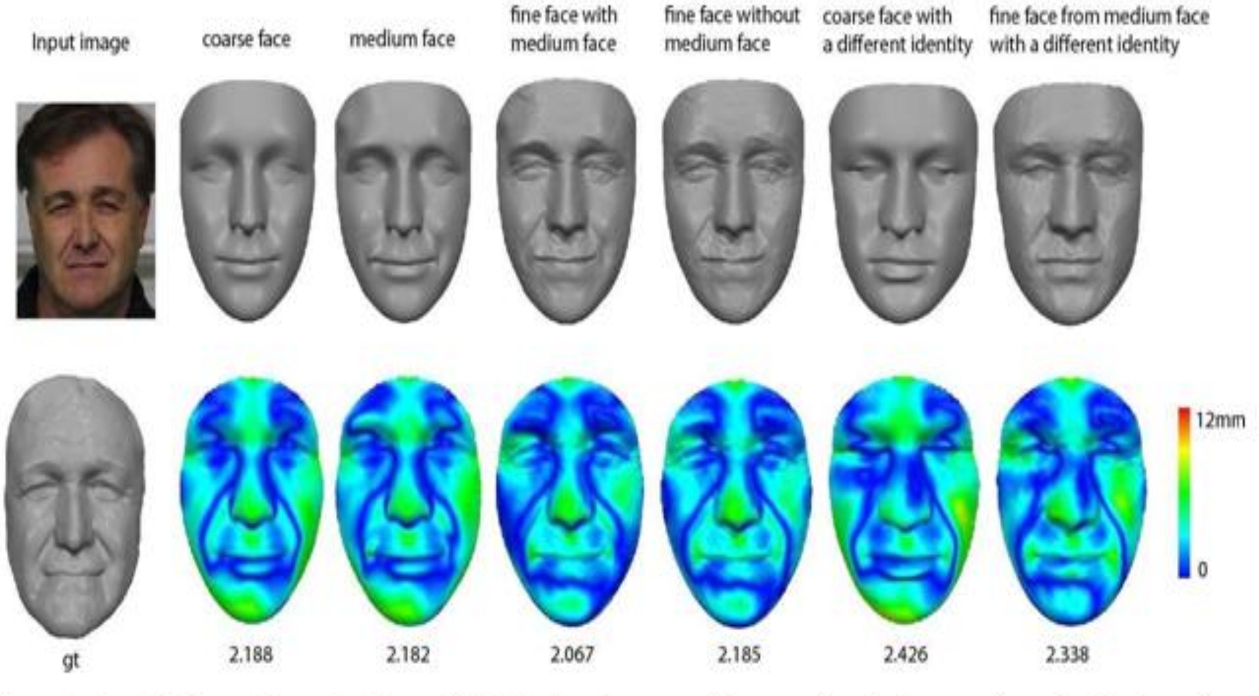

Fig. 3: Different face reconstructions and their corresponding error maps an example-basedbilinear face model is first used to generate a smooth, coarse 3D face by aligning the projection of the 3D face landmarks with the 2D

landmarks found in the input image. The coarse 3D face is then refined using photometric consistency constraints and local corrective deformation fields, yielding a medium face shape.

Yudong Guo, Lin Cai, Juyong Zhang [4], we outline an innovative technique for jointly learning a 3D face parametric model and a 3D face reconstruction from various sources. Previous techniques often learned 3D face modeling from a single type of source, like scanned data or photos found in nature. Despite the fact that 3D scanned data contains precise geometric information about the shapes of faces, the capture system is expensive, and such datasets typically only include a few subjects.

Fig. 4: Real-Time Dense Face Reconstruction from A Monocular RGB Video

On the other hand, it is simple to acquire in-the-wild face photos and there are many of them. However, precise geometric information is absent from facial photographs. In this article, we suggest a technique for developing a unified face model from various sources.

G C Feng and PonG C Yuen J H Lai [5], a person's face is represented in 3D, it is possible to create 2D views of them. In order to accurately identify a person's face model from a single image of them in various stances and expressions, this study suggests a new technique dubbed 3D spring-based face model (SBFM). The SBFM combines the ideas of a deformable template with a generic 3D face model from computervision. We tested our suggested method using face image databases from Yale University and the MIT AI lab, and the results are promising. This research suggests using a generic 3D face model to create many views from a single known-pose photograph.

METHODOLOGY

The process starts with a single 2D image as input, three processes make up our method: features extraction, depth estimation, and 3D picture production. Facial feature computation and SIFT feature calculation are subcategories of feature extraction. Shape from shading and Multivariate Gaussian distribution (MVGD) techniques is used to calculate depth. The Basel face model is used in the third step to produce 3D photos.

A. Feature Extraction.

There are two more steps in the features extraction process. First, the extraction of face characteristics such the nose, eyes, lips, and mouth occurs. SIFT is then employed to extract distinguishing features. A single 2D image is used as input in this step. The image is first checked for the presence of faces. The supplied image is processed further if it contains a face. On the face, many markers are localized. Images from the LFW database are being used for testing. A boosted frontal profile face detector is used to advance the Viola-Jones method, which is used to find faces. Near the right and left eyes, mouth, chin, and cheek boundaries, 68 landmarks are marked.

B. Depth Estimation

This section estimates the depth of the input image. The distance between the sensor and the table surface is called the depth. It is a necessary step to understand 3D geometry. The estimation consists of two parts. First, the depth is calculated using the multivariate Gaussian distribution (MVGD). Then the extended details are calculated. Using a shape from a shading technique. Depth is calculated from a single image using MVGD. Before this step, the image has two dimensions. By assigning depth as the third dimension to an image, the image can be rotated and translated at will.

C. Creation of 3D Image

After completing the previous steps, we have data in three directions, allowing us to integrate our data into a morph able 3D model. A publicly accessible face model from Basel was used. It consists of 3D scans of 100 women and 100 men. We have three-dimensional data and BFM. To fit this model, our main goal is to minimize the sum of squared pixel differences between the processed image and the given model.

CONCLUSION

The process of generating 3D facial images from a single 2D image involves three main steps: feature extraction, depth estimation, and 3D image creation. The feature extraction process involves identifying and extracting facial features such as the nose, eyes, lips, and mouth using a boosted frontal profile face detector and SIFT feature extraction. The depth estimation step utilizes multivariate Gaussian distribution and shape from shading techniques to estimate the depth of the input image. Finally, the 3D image creation step involves integrating the data from the previous steps into a morph able 3D model using the Basel face model and minimizing the sum of squared pixel differences between the processed image and the model. This method has several advantages, such as the ability to generate 3D facial images from a single 2D image, which is useful in applications such as computer vision, facial recognition, and virtual reality. The use of the Basel face model and multivariate Gaussian distribution and shape from shading techniques also allows for more accurate and realistic 3D images to be generated. However, there are also some limitations to this method, such as the requirement for high-quality input images and the potential for inaccuracies in the feature extraction and depth estimation processes. The process of generating 3D facial images from a single 2D image is a complex and challenging task that requires advanced techniques and algorithms. With further research and development, this method has the potential to become even more accurate and useful in various applications.

REFERENCES

[1]. Feng Liu Member, IEEE, Qijun Zhao, Member, IEEE, Xiaoming Liu, Member, IEEE, and Dan Zeng. Publisher: IEEE Transactions on Pattern Analysis and Machine Intelligence (Volume: 42, Issue: 3, 01 March 2020) "JOINT FACE ALIGNMENT AND 3D FACE RECONSTRUCTION WITH APPLICATION TO FACE RECOGNITION".

[2]. Xiaoguang Tu, Jian Zhao and Akshaya Balamurugan, Member, IEEE "3d face reconstruction from a single image assisted by 2d face images in wild*" in 1160 IEEE transaction on multimedia, VOL. 23, 2021,* doi**:** 10.1109/TMM.2020.2993962

[3]. Luo Jiang, Juyong Zhang, Bailin Deng, and Hao Li,and Ligang Liu, Member IEEE "3d face reconstruction with geometry details from a single image" *IEEE transactions on image processing, VOL. 27, NO. 10, OCTOBER 2020* doi:10.1109/TIP.2018.2845697,

[4]. G C Feng and PonG C Yuen J H Lai "Virtual view face image synthesis using 3d spring-based face model from a single image" *Proceedings, Fourth IEEE International Conference on Automatic Face and Gesture Recognition (Cat. No. PR00580) 28-30 March 2000* doi: 10.1109/AFGR.2000.

[5]. Yudong Guo, Lin Cai and Juyong Zhang Members IEEE "3D Face From X: Learning Face Shape From Diverse Sources" *IEEE Transactions on Image Processing (Volume: 30) 18 March 2021* doi: 10.1109/TIP.2021.3065798.

[6]. "3D Face Reconstruction from a Single Image Using a Multi-Modal Multi-Task Deep Neural Network," by J. Deng, S. Cheng, N. Xue, and Y. Zhou. Published in IEEE Transactions on Image Processing in 2021. DOI: 10.1109/TIP.2021.3068084

[7]. "A Multi-View 3D Face Reconstruction Approach with Deep Learning," by Y. Cai, Z. Wang, Y. Huang, and J. Cao. Published in Journal of Visual Communication and Image Representation in 2021. DOI: 10.1016/j.jvcir.2021.103209

[8]. "Single-Image 3D Face Reconstruction with Pixel-Wise Depth Regression," by Z. Cao, S. Saito, Y. Ushiku, and T. Harada. Published in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 2018. DOI: 10.1109/CVPR.2018.00028

[9]. 3D Face Reconstruction from a Single 2D Image: A Survey," by A. Zou, X. Wu, J. Yang, and Q. Ji. Published in Image and Vision Computing in 2020. DOI: 10.1016/j.imavis.2020.104058

[10]. "Robust 3D Face Reconstruction from Single Images Using a Hybrid, Generative-Discriminative Model," by S. Saito, Z. Huang, R. Natsume, S. Morishima, and A. Kanazawa. Published in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 2017. DOI: 10.1109/CVPR.2017.782

[11]. "3D Morphable Face Models - Past, Present and Future," by T. Vetter, V. Blanz and T. We rich. Published in Computer Graphics Forum in 2018. DOI: 10.1111/cgf.13367

[12]. "3D Face Reconstruction Using Photometric Stereo: A Survey," by Y. Wei, Z. Liu and H. Zhang. ublished in Journal of Visual Communication and Image Representation in 2018. DOI:10.1016/j.jvcir.2018.06.004

[13]. "3D Reconstruction of Human Faces with Convolution Neural Networks," by P. Dou, S. Zhang, and Z. Wang. Published in Proceedings of the International Conference on Multimedia Retrieval in 2018. DOI: 10.1145/3206025.3206031
[14]. "A Survey on 3D Face Reconstruction," by S. Saito, Z. Huang, and H. Li. Published in ComputerVision and Image Understanding in 2019. DOI: 10.1016/j.cviu.2019.102831
[15]. "Efficient 3D Face Reconstruction from Multiple Images Using Quality Measures," by R.Qian, J. Wright, L. Zhou, and Y. Li. Published in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 2014. DOI: 10.1109/CVPR.2014.192
[16]. "3D Face Reconstruction Based on Feature Matching and Patch-Based Refinement," by Y. Liu, J. Liu, and H. Zha. Published in IEEE Transactions on Multimedia in 2018. DOI: 10.1109/TMM.2017.2768539
[17]. "Real-Time 3D Face Reconstruction from Single 2D Image by Fast-Forwarding Regularized Landmark Optimization," by X. Yu, Y. Liu, S. Xiang, and M. Song. Published in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 2019. DOI: 10.1109/CVPR.2019.00763
[18]. "A Unified 3D Face Reconstruction Framework Based on Fractal Theory," by Y. Zhang, Q. Wang, Y.Zheng, and W. Liu. Published in IEEE Transactions on Multimedia in 2019. DOI: 10.1109/TMM.2018.2885518
[19]. "3D Face Reconstruction from a Single Image Using Convolution Neural Networks and Shape-from-Shading," by D. T. Nguyen, D. J. Park, and I. S. Kweon. Published in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 2018. DOI: 10.1109/CVPR.2018.00177
[20]. "3D Face Reconstruction from Single 2D Image by Structural-Preserving Shape Generation," by L. Guo, S. Huang, and L. Huang. Published in Proceedings of the IEEE Conference of Computer Vision and Pattern Recognition (CVPR) in 2019. DOI: 10.1109/CVPR.2019.00838