A Survey of Face Morphing Techniques

D.R.Kasat[1], Sanjeev Jain[2], Ph. D, V. M. Thakare[3], Ph. D
[1] Associate Professor, Sarvajanik College of Engg & Tech., Athwalines , Surat,
[2]Director, MITS, Gwalior
[1] Professor and Head Of Deptt.,CSE, Amravati University,Amravati

Abstract
Nowadays, face morphing is used in various fields of works such as computer animations, games and movies. Face morphing is an effect that shows a transition from one face image to another face image smoothly. Research on face morphing is as vast as the many interests and needs that can be found in the general public, television or film production. In this paper, we thus review the different morphing techniques that can be used to generate and manipulate faces. Due to the advantages in applying face morphing in various kinds of work, there are several works on face morphing and we can categorize them into three groups, based on their corresponding fields of works as Face Transfer, Facial Animation and Enhancement of Facial Attractiveness.

Keywords
Face morphing, Image morphing, Face replacement, Video morphing, Face alignment, Morph-able Model

INTRODUCTION

Morphing images of one face into another is great fun. Morphing is the process of creating a smooth animated transition from one picture into another. Using morphing we can add stunning effects into our home-made videos, create visual jokes for our friends, or master a unique animated avatar to represent oneself in on-line communities. You'll easily find many more funny uses on your own. So, let's concentrate on the technical side.

Much empirical work has focused on the perception and processing of human faces. For many experiments, researchers have generated artificial faces using a variety of techniques. Also there are many professional applications that can create video effects. They produce great animations that are used in million-dollar movies.

The inherent difficulty in accurately manipulating the human face is that even the average viewer can easily determine the error in the visual appearance of the human face in an image or a video. One need to understand the specifics of the human face to create a system that allows unskilled users to apply stylistic exaggeration to photographs/videos with a less developed spatial skill set. Visual stylization is highly appealing to the eye and serves many artistic and commercial purposes. However, mastery of visual stylization is inherent to skilled artists, as it often requires a solid background in three-dimensional space and realistic anatomy; colloquially, ―learn the rules before you break them.‖

In this paper, we thus review the different morphing techniques that can be used to generate and manipulate faces. Due to the advantages in applying face morphing in various kinds of work, there are several works on face morphing and we can categorize them into three groups, based on their corresponding fields of works as

A. Face Transfer

B. Facial Animation

C. Enhancement of Facial Attractiveness

Some of the works in three categories mentioned above employ 2D/3D Morphable Model.

A. Face Transfer
Face Transfer is a method for mapping video recorded performances of one individual to facial animations of another. Techniques for manipulating and replacing faces in photographs have matured to the point that realistic results can be obtained with minimal user input.In recent times, certain methods allowed for automatic face replacement of people in single image [2-3]. For example, the method by Blanz et al. [2] fits a morphable model to faces in

both the source and target images and renders the source face with the parameters assessed from the target image. Finally it replaces the target face with source face in target image. Morphable model is built from a statistical analysis of human faces, obtained from a large database of 3D scans, which can be morphed by adjusting parameters. It can estimate 3D shape of human face, its orientation in the space, and illumination conditions in the scene. Thus the reconstructed face extracted from 2D image can be manipulated in 3D [1]. Bitouk et al. [3] describe another system for automatic face swapping using a large database of faces. System allows de-identification automatically which select candidate face images from a large face library that is similar to the target face in appearance and pose. However, it is hard for users to find a candidate face to match the target face in appearance and pose from their own images and replace the target candidate with selected candidate from the library image using image based method.

In first method, during an initialization step, the shape parameters of the model are fitted to both human faces. Then, these parameters are varied to obtain the structure of the face in a deformed shape, but in the same pose. To show this deformation in a video, it has to be performed in each and every frame. So it is clear that this methodology can be applied but have to handle some challenging problem to perform automatic face replacement in video and to maintain spatial and temporal coherence.

Face replacement in video, however, poses significant challenges due to the complex facial geometry as well as our perceptual sensitivity to both the static and dynamic elements of faces. Certain methods have been proposed which allows replacing face in video automatically by solving the various challenging problems [4-8]. Essentially, there are three basic steps to replace face in video as shown in [Figure. 1].

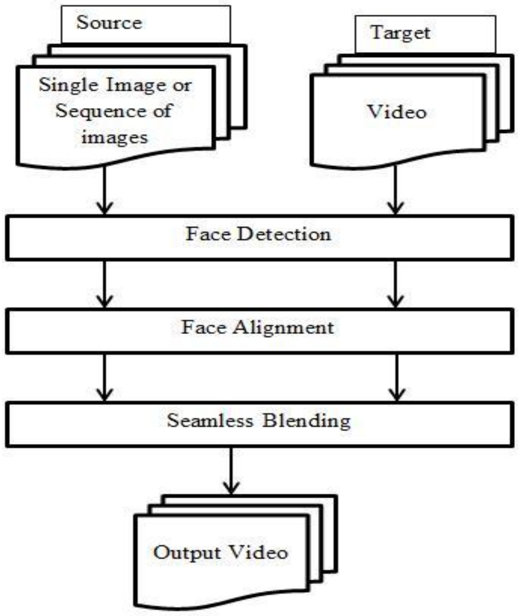


Figure 1: Basic steps for face replacement in video

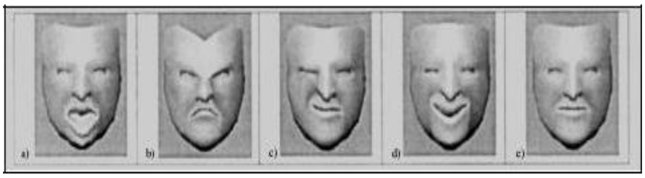
A face detection algorithm should locate the positions of the character human precisely. However, it is not enough for knowing where the face appears in a video. To replace the face, System has to detect not only the face, but also the outlines of the facial profile and structures. Thus, a face alignment algorithm plays a critical role in these systems. The eventual result is ended by pasting up the synthesized sequence onto the target character's face. A visually convincible output video is done by blending the synthesized sequence and the target video together seamlessly. The following Table 1 depicts the comparative study of the techniques [4-8] providing face replacement in video with various scenarios.

Table 1: Comparison of Different Techniques

Method	**Pros**	**Cons**
Image Based Face Replacement in Video[4]	Less time complexity because of Image based method It can be used for entertainment purpose	Facial expression and pose would be same It requieres to shoot target video with facieal expression and pose similar to the source video It requieres maual inputs in clustering process The tolerance to pose variance is limited by the robustness of face alignment algorithm
3D Morphable Model Based Face Replacement in Video[5]	Here source is reduced to single image It takes care of facial expession and pose of target face	Time comsuming process because of 3d model based method The tolerance to pose variance is still limited by the robustness of face alignment algorithm
Automatic Face Replacement in Video Based on 2D Morphable Model [6]	This approach is fully automatic without user interference Less time comsuming process because of 2d model based method	It does not take care about facial expression The tolerance to pose and expression variance is limited by the robustness of ASM Sharp lighting and violent movement in videos may affect the final result
Video Face Replacement [7]	It gives plausible results This approach is fully automatic with less user interference It takes care about facial expression	Tracking is based on optical flow, which requires that the lighting change slowly over face Tracking often degrades beyond the range of poses outside 45^0 from frontal. Lighting must also be similar between source and target.
Face Replacement in Video from a single image[8]	It works very well for non-frontal face. This system is able to replace the target face with another face of an entirely different pose and animate the new face based on the original speech in the video.	High complexity

B. Facial Animation

Morphing is often used in facial animation, and consists of mixing several expression models. The basis of morphing, in its traditional use, is simple as shown in (Figure 2) of [13]. As face databases are of great value in face-related research areas in both modeling and support of methods, many researchers built their own face database for specific applications. Some of these face databases are composed only of 2D face images, while others contain 3D shape information. Some of them contain only one static expression (the neutral face), which is mostly used in applications involving only static faces, e.g. face recognition; while others also contain other expressions, which can be used in face motion-based applications, e.g., face expression recognition and tracking, and face reanimation in still images and video sequences. The animator must give, with respect to a given referential, a reference model Tref (also called neutral model), and as many other deformation models Tj as he wants (also called expression models). This is a challenging task, since human faces are highly non-rigid and could perform large 3D shape deformation under expression and pose variations. Once these stages of modeling are achieved, the software expresses the deformation models Tj in terms of displacement vectors with respect to the reference Tref.



(a) (b) (c) (d) (e)

Figure 2[13]. -- a-d) Examples of expression models (Tj). e) The neutral model Tref associated to the preceding expression models.

Face manipulation is a convenient tool for artists and animators to create new facial images or animations from existing materials, and hence of great research interest in computer animation. Recently, 3D face models have become increasingly popular in complex face manipulation. Blanz et al. [17] reanimate the face in a still image or video by transferring mouth movements and expression based on their 3D morphable model [1] and a common expression representation. They also exchange the face between images across large differences in viewpoint and illumination [2]. Yang et al. [16] derive an expression flow and alignment flow from the 3D morphable model between source and target photos, capable of transferring face components between the images naturally and seamlessly. Shilizerman et al. [27] generate face animations from large image collections.

C. Enhancement of Facial Attractiveness

Aesthetics and beauty have captivated human beings from the very dawn of mankind, inspiring myriad artists and philosophers. However, an absolute definition of aesthetic values remains vague. Over centuries, the common notion in this research has been that beauty is in the eye of the beholder—that individual attraction is not predictable beyond our knowledge of a person's particular culture, historical era, or personal history. However, more recent work suggests that the constituents of beauty are neither arbitrary nor culture bound. Different studies have examined the relationship between subjective judgments of faces and their objective regularity.Nevertheless, although the literature on facial attractiveness is vast [12, 14, 19, 20], most of which falls into the psychological category yet ignores the establishment of the computational models. Computational facial attractiveness analysis aims to predict the beauty score of a face and quantitatively reveal the consistent relations between attractiveness and various facial features (small nose, high forehead, prominent cheekbones, arched eyebrows, etc.). Such computational models are meaningful due to their theoretic implications and practical usage. For example, in online dating applications, by asking the user to rank as elected subset of candidates, the service provider is able to make prediction to the rest of its database and proposes better recommendation. Another potential application is face beautification, which rearranges the geometric layout of facial landmarks and modifies other facial properties like skin colours. A computational model can be used to evaluate the refined faces by a face beautification system. Roughly, prior studies can be cast into the following lines based on the adopted features:

Geometry-based methods: The work in [21] analyzed the role of geometry in the determination of attractiveness of a face. On their constructed 452-image face database, the authors first located 29 landmarks residing on critical regions such as eyes or nose. Afterwards, various geometrical features were extracted based on golden ratios [22], facial symmetry or neoclassical canons [23] (e.g., nose length=ear length).Those heterogeneous features were finally fused to train the facial attractiveness predictor.

Appearance-based methods: In the recent work of Grayetal. [24], the authors represented each cropped face using overlapping patches. Each patch was convolved with 48 local filters and followed by a non-linear logistic transformation. The procedure is repeated on multiple scales to capture omni-scale discriminating features. The extracted feature vectors are then fed into a classical linear regression model for parameter learning. Other appearance-based algorithms can be found in [25].

Hybrid methods: Eisenthaletal. [18] utilized two kinds of features, including the manual measurement of 37 facial feature distances and ratios that reflect the geometry of the face (e.g., distance between eyes, mouth length and width), together with the simple concatenation of gray-scale pixels. The combination was motivated by the observation that the best ratings achieved using each individual feature had a lowcorrelationof0.3–0.35 with each other, which suggested that the geometry and appearance information are potentially complementary. The empirical evaluations in [18] clearly supported this hypothesis. Other modalities are also proved to be useful as demonstrated in [26], where for each face, information such as Hue, Saturation and Value (HSV) values of hair colour and skin colour, and a measurement of skin smoothness are also employed. There are also applications beyond facial beauty ranking. For example, Leyvand et al. [15] proposed an example-guided enhancement of facial attractiveness. A crucial component in their system is a trained facial attractiveness engine. For each face to be processed, the algorithm searches the face space for a nearby point with a higher predicted attractiveness rating and then deforms the original face in 2D warp field accordingly.

CONCLUSION

In this paper, we have surveyed the growth of face morphing and described recent advances in the field. The ease with which an artist can effectively use morphing tools is determined by the manner in which these components are addressed. We surveyed various face morphing techniques, including those based on model based and image based morphing for images and video sequences. For those cases where the input images are sufficiently similar, feature specification can potentially be automated. So the feature extraction is the key technique toward building entirely automatic face morphing algorithms.

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