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Literature Review 3

In this Literature Review, I reviewed two articles regarding scanning human faces geometry and presented in computers. Both articles talked about the specific procedures for how to modeling human faces into computers. However, they varies by equipments, methods, and computation models. The first article “Multi-scale capture of facial geometry and motion” was published in ACM SIXGRAPH 2007 by Bernd Bickel. [Bernd Bickel, 2007] The article mainly discussed the current 3D scanning models and methods that we used in 2007 and later the article proposed a solution about how to solve detailed face motion capture (such as wrinkles, head pose) in a relative efficiency way. The later article “Blending Face Details: Synthesizing a Face Using Multiscale Face Models” was published in IEEE Computer Graphics and Applications 2017 by Seung-Hyun Yoon. [Seung-Hyun Yoon, 2017] Besides how to implement the human face geometry from the human, this article mainly focuses on: after implemented different face geometries, how to assist artists to blend in different face models to create a cinema effect’s design.

As is, the article published in 2007 helped users to increment the reality of the face geometry. The later articles can use the face models that were created and generated a computer graphics design. This is very helpful in filming industries such as animating the after effects or creating generic models (Such as human models and dog models blended in.). Differ from the perspectives and goals of the two articles, they required different types of equipment and computation speeds. For example, In order to capture the details of human faces, the first article used a high-resolution face scanning system from 3QTech. [Bernd Bickel, 2007] This generate a static, high-resolution face mesh. Then they used six Basler cameras running at 50 fps to capture a faster, large-scale face motion by tracking 80-90 marker points on human faces. To even acquire the details such as wrinkles, they used the Basler cameras with 12.5 fps to generate the slower, medium-scale wrinkles expressions. All of this equipments are professional and not to easy obtained by individuals.

The newer article that was published in 2017 has another perspective in face models design. The main goal of this article is to help the artists from entertainment industries to generate and modify 3D face models in a simple, efficient and powerful ways. The face blended techniques don’t require a lot of industry-leveled equipment. In the article, the artist can run and analyze the models by using Intel Core2 Duo 2.80-GHz CPU with a 4-Gbyte main memory and a Nvidia GeForce 9600 M GT Video card, which can be found in most home computers. [Seung-Hyun Yoon, 2017] Besides the equipments difference, we can also clearly see that: Even though it is only 10 years difference for these two articles, the methods and technique equipments had been improved a lot as well as more easy to access by individuals. For instance, in the first article, the authors were only able to track 80-90 markers on human faces where the new iPhone X can capture more than 30, 000 infrared dots on human faces. [Andy Greenberg, 2017] Thus, when the second articles was published, thanks to the technology advance, the film industries can create 3D face models in minutes where they used to be days to product the 3D face models.

Even though the hardware equipment had been improved a lot, from the methods and algorithms, we can still found they shared a lot of similarities between the two articles. In the articles in 2007, after capturing the high-resolution face mesh (Face Space), large-scale face motion (Mocap Points) and medium-scale expression wrinkles by using the cameras and scanning system, they used radial basis functions (RBFs) to map the mocap points into the 3D scan F (Face Space), since 3D scan F and mocap points have different coordinate systems. [Bernd Bickel, 2007] Then they deform the initial face mesh by applying a linear deformation model. Later on, they added medium-scale expression wrinkles into the face mesh. To track the wrinkles efficiency, they used support vector machine to find image pixels associated with each predefined wrinkles and use uniform B-Spline curve to find the wrinkle patches. Besides all the procedures above, they also need to estimate cross-section in wrinkles, synthesizing the medium-scale expression wrinkles into the face mesh and removing the wrinkles due to the computation errors.

After all the processing above, a 3D face models including wrinkles was captured in computers. As we can see clearly, each step require a lot of computation space as well as computation power. For each video frame, the wrinkles-capture takes 5s and 8 minutes to compute the cross-section.[Bernd Bickel, 2007] Overall, Each frame needs 10 minutes to generate. Besides, this models can only be used for performance capture and reply. People cannot change the parameters in the models to modify the 3D faces. Another drawback of this model is: they are not able to capture other components of the face such as eyes or teeth. Thus, from here we can see, by 2007, the 3D face technology is still limited either by equipment or models. It can also associate with a higher cost due to the running time of the models and the restriction of the equipment.

Judging by the articles from 2007, we can see that the movie's post-production take a lot of times and costs, as well as certain limitations. Especially if the movies need to create some fake 3D characters, such as Thanos from the avenger 3. If a character is not in human forms, it needs a lot of artists to sculpture the character as well as to 3D scanning the character into the computer. The article that was written by Seung-Hyun Yoon in 2017 provides an easy-to-access and powerful technique to solve the limitations in movie productions. Thanks to the hard works from previous articles, they can generate a multiscale face model (MFM) with detailing like wrinkles in a relatively short time. In the MFM, it provides full details from coarse to fine scales as well as all the face's parameters. The new models can achieve mesh correspondence, parameterization and multiresolution techniques at ease, so the user don ‘t need to worry about different coordinate systems or how to map from one resolution to another. In order to blend different face models fast and efficiency, they used weighted blending techniques that can blend spatial details in different face models.

In order to approximate multi-scale displacements into a common parameter space, they used the multilevel B-spline technique. Then they constructed the face model M by adding a set of continuous displacement maps (CDMs) where CDMs are grouped by the displacement functions. [Seung-Hyun Yoon, 2017] To include a coarse-level displacement, they just need to modify the face model M by plus the base function and its vector displacement. The good things about CDMs is, you can create as many levels of CDMs as you want. Also the calculation of face model M is linear, so it is also computation efficiency as well.

Then the article is detailing about how they blending CDMs at different levels, such as providing a user-specified feature curve. This feature curve can provide a detailed coherence among different levels of CDMs, which can help to blend the human and nonhuman faces easily. [Seung-Hyun Yoon, 2017] Later on they also used a smooth deformation function to correspondence different parameter spaces. Moreover, since they can correspondence different parameter spaces, they can use the weighted blending technique of the MFMs to synthesize a new 3D face model.[Seung-Hyun Yoon, 2017] For example, given a human face 3D model and a tiger face 3D model, if the ratio of blending is 0.8: 0.2 for human face via tiger face, the synchronizing face will have more human characters then the tiger characters. From their built-in models, it allows the artist to modify the 3D faces freely and efficiently.

To test their face blending techniques, the authors created 15 different face models to allow the artists to play around with it. Each face is an MFM which contains a base surface and four CDMs levels. Each MFM can be blending using different blending weights. By controlling the blending details, artists can blend human and nonhuman faces at ease. Moreover, by applying the feature curves, the models can transfer face details to an abstract face, such as controlling the shape of noses, eyes...etc. Due to the flexibility of the models, it can also be used to edit details even when the face is ambiguous. Besides that, most operations are linearity, thus guarantee computation efficiency. The models were performed by 10 artists and each artist was given 10 minutes. After the practice, the models were rating by the artists with the highest score is 5 and the lowest score is 1. The mean scores of the experiments are 4.

From the newest article, we can see that modeling 3D models in computers improve a lot in recent years. It not only make the modeling process more easy to perform, it also makes the process more easy to access to everyone. Not to mention due to the high production in these days, the cost of creating 3D effects dropped dramatically. It also can be seen from the movie industries as well, recalling the sci-fiction movies at the earlier 2000, the movies at that time were low on technology and most scenes can be identified as “fake” through our eyes. Nowadays, movies created with scenes about outer space are so real and so convincing. It is the first time in the history that we can create a 3D scene to capture the beauty of the galaxy that we don’t need an expensive telescope to explore it. However, even though the older the article is low on production and efficiency, we still need to appreciate its efforts. Without all those milestones in Computer Graphics history, there is no way we would be able to experience the benefits of technologies that we have today.

Reference:

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journal={IEEE Computer Graphics and Applications},
title={Blending Face Details: Synthesizing a Face Using Multiscale Face Models},
year={2017},
volume={37},
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keywords={computer graphics;2D parameter space;3D face mesh;CDMs;MFM;computer graphics;face details;multiscale continuous displacement maps;multiscale face models;nonhuman characters;salient facial features;weighted multiscale detail blending;Computational modeling;Face recognition;Semantics;Shape analysis;Solid modeling;Splines (mathematics);Three-dimensional displays;blendshapes;computer graphics;continuous displacement maps;face modeling;multilevel b-spline;multiscale face model;parameterization},
doi={10.1109/MCG.2017.4031069},
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author = {Bickel, Bernd and Botsch, Mario and Angst, Roland and Matusik, Wojciech and Otaduy, Miguel and Pfister, Hanspeter and Gross, Markus},
title = {Multi-scale Capture of Facial Geometry and Motion},
journal = {ACM Trans. Graph.},
issue_date = {July 2007},
volume = {26},
number = {3},
month = jul,
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articleno = {33},
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acmid = {1276419},
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address = {New York, NY, USA},
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3) Andy Greenberg
https://www.wired.com/story/tried-to-beat-face-id-and-failed-so-far/

APA Citations:

1)S. H. Yoon, J. Lewis and T. Rhee, "Blending Face Details: Synthesizing a Face Using Multiscale Face Models," in *IEEE Computer Graphics and Applications*, vol. 37, no. 6, pp. 65-75, November/December 2017.
doi: 10.1109/MCG.2017.4031069
keywords: {computer graphics;2D parameter space;3D face mesh;CDMs;MFM;computer graphics;face details;multiscale continuous displacement maps;multiscale face models;nonhuman characters;salient facial features;weighted multiscale detail blending;Computational modeling;Face recognition;Semantics;Shape analysis;Solid modeling;Splines (mathematics);Three-dimensional displays;blendshapes;computer graphics;continuous displacement maps;face modeling;multilevel b-spline;multiscale face model;parameterization},
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