A Visual Representation for Editing Face Images Supplementary Materials

Jiajun Lu[1], Kalyan Sunkavalli[2], Nathan Carr[2], Sunil Hadap[2], David Forsyth[1]

[1]University of Illinois at Urbana Champaign, [2]Adobe Research
[1]{jlu23, daf}@illinois.edu, [2]{sunkaval, ncarr, hadap}@adobe.com

1 Face Relighting Results

The full version of Figure 6 (face relighting) in paper is shown in Fig. 1 here. Beside these, we include lighting tables with each subject under six different spherical harmonic lighting conditions. In Fig. 2 and Fig. 3, each row is a subject, and each column shares the same lighting condition. The first column is the original image. For example, image with row index i and column index j means the ith image is relighted with the jth lighting condition.

2 Face Relighting Comparisons

Figure 5 in paper compares our relighting method with [3], the full version of the figure is shown in Fig. 4. We include both our relightings with spherical harmonic lights and directional lights. Both lights create more realistic images than those of [3].

Scattering: We simulate scattering effects by smoothing shading, see Sec. 4.1 in original paper. We include our results with smoothed shading and without smoothed shading in Fig. 6. Smoothed shading yields softer shadows and more realistic images.

Detail map: The full version of Figure 4 in paper is shown in Fig. 5 here.It compares our method to baseline rendering methods. Removing the detail map produces overly smooth faces, and using multiplicative detail loses detail in dark or bright areas.

3 Makeup Transfer Results and Comparisons

The full version of Figure 7 in paper is shown in four figures here:

- Same gender transfer, refer to Figure 7.
- Across gender transfer, refer to Figure 8.
- One reference transferred to multiple inputs, refer to Figure 9.
- Multiple references transferred to one input, refer to Figure 10.

Transfer tables: Transfer table for multiple paintings transferred to multiple models are included here. We have three categories of transfer tables: transfer makeup to women, transfer makeup to men, transfer no makeup face to no makeup face. We include two tables for each category, one with whole image, and the other with face area masked out. Results look much better with masked faces because of the contrast.

– Transfer makeup to women, refer to Figure 11 for full images, and Figure 12 for masked out faces.
– Transfer makeup to men, refer to Figure 13 for full images, and Figure 14 for masked out faces.
– Transfer no makeup face to no makeup face, refer to Figure 15 for full images, and Figure 16 for masked out faces.

Besides the comparisons in the paper, we compare to the method of [4] (who use a physical model for skin appearance to simulate makeup), refer to Fig. 17.

The full evaluation table for the online attractiveness is shown in Table. 1.

4 Detail Editing Results

We transferred the same shiny nose to a group of subjects, see Fig. 18. The missing left part of the nose tip (blocked in original image) creates a little problem on some images, but it's easy to fix by synthesizing detail map to fill in holes (future work).

The full version of Figure 10 (detail transfer) in paper is shown in Fig. 19 and Fig. 20 here. The left part of Figure 10 in paper transfers only part of the detail maps, corresponding to Fig. 19 here (the areas that are transferred are labeled); the right part of Figure 10 in paper transfers all the nine parts (left eyebrow, right eyebrow, left eye, right eye, forehead, nose, mouse, left cheek and right cheek), corresponding to Fig. 20 here.

Beside these, we create a detail transfer table in Fig. 21 and Fig. 22. For 9 different subjects (row), we transfer 11 different face detail maps (column). In this table, we transfer the full detail maps to make the limited images more informative. Actually, parts transfer are needed in lots of applications. The first row of the transfer table is the source where the detail map comes from, and the first column is the original image. For each image with row and column index i and j, we transfer the face detail map of the jth source image to the ith original image.

5 Detail Editing Comparisons

We compare our appearance editing results with [1]. [1] edits image layers to create different material effects, while we use nonparametric detail transfer to change surface details. We can change both skin materials and small face expressions. Our results depend on the source image, while their results depend on an appropriate choice of parameters. While this is an apples-to-oranges comparison, we present it to show that detail transfer can minic the results from [1] (Fig. 23 and Fig. 24).

6 Applications

Our model can be used for lots of application scenarios. We group these scenarios into relighting based scenarios and transfer based scenarios. Relighting based scenarios include adding shadow on face, using spotlight to make face ”stick out” and weakening shadow on face. Transfer based scenarios include makeup transfer, transferring skin property, transferring wrinkle, adjusting nose, changing shininess of face. For relighting related application scenarios, see Fig. 25; for transfer related application scenarios, see Fig. 26.

7 User Study

We include images for our user study in Fig. 27. There are in total 12 tasks: task 1 uses our method to perform minor change to spherical harmonic lights; task 2 uses our method to perform significant changes to spherical harmonic lights; task 3 uses our method to transfer face details; task 4 uses our method to both change lights and transfer face details; task 5 uses average face (no mesh morphing) to relight; task 6 uses average face to transfer face details; task 7 uses the no detail map method; task 8 uses multiplicative detail (shading ratio); task 9 uses Portrait Pro 15; task 10 comes from [3]; task 11 comes from [5]; task 12 comes from [2]. In each pair (Image 1 and Image 2), the one in red box is our edited image. We also include the original image of the edited image as the third one. The user study interface is shown in Fig. 28.

8 Limitations

There are some limitations in our methods. First, lights need to be appropriately selected, and wierd lights will create wierd results. Second, error in alignment creates some problems. To solve this problem, improvements in tracking and 3D modeling are needed. Third, occluded features (like mouth open and mouth closed, occluded face or nose) create problems in our current system. But we can handle this problem by improving mesh quality in morphable face model and using synthesis to fill in the missing parts. Fourth, new features create some problems, such as transferring a man’s moustache to a women. Last, transfer need to make sense. Transferring only one eye makes results wierd. We include some failure examples in Fig. 29.

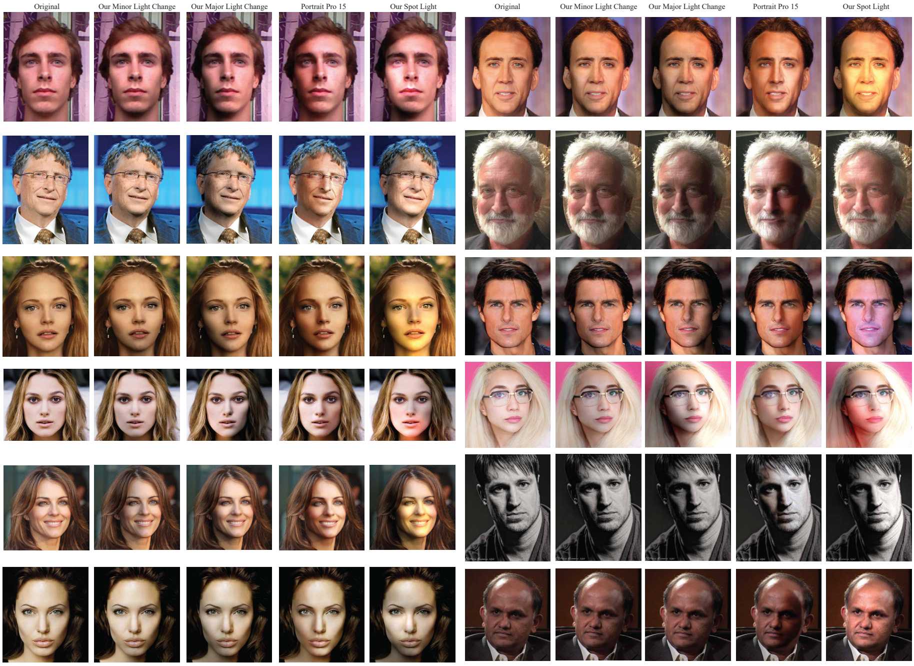


Fig. 1. Full version of Figure 6 in paper. Face relighting. Each row shows the original image, our results with minor/major changes to lighting, a result from Portrait Pro 15, and our addition of spot lights. Best viewed at high resolution in color.

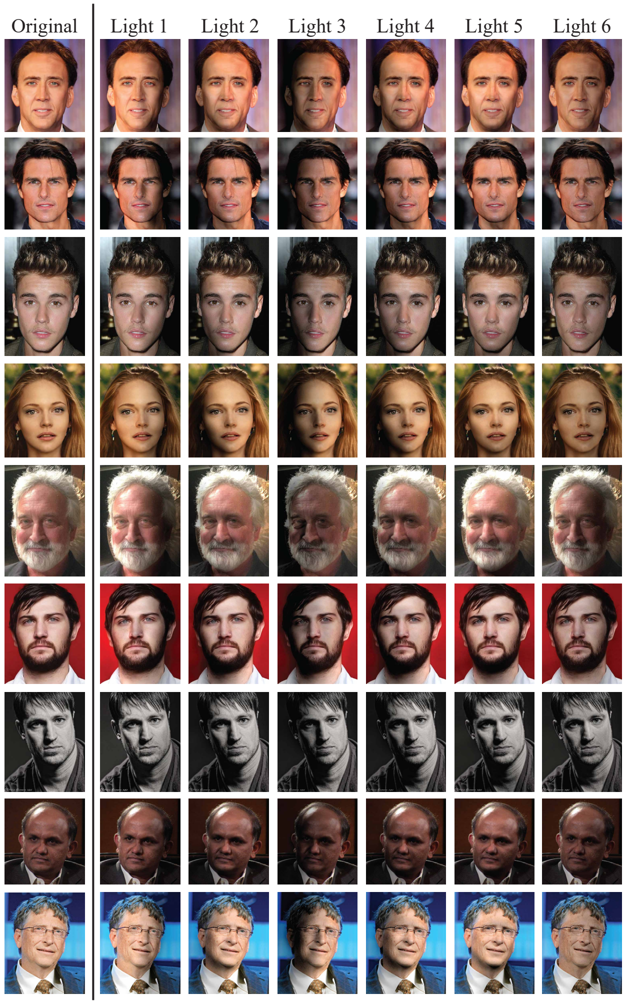


Fig. 2. Relighting Table Part 1. Relighting the image according to several lighting conditions. Each row is one subject, each column is one lighting condition.

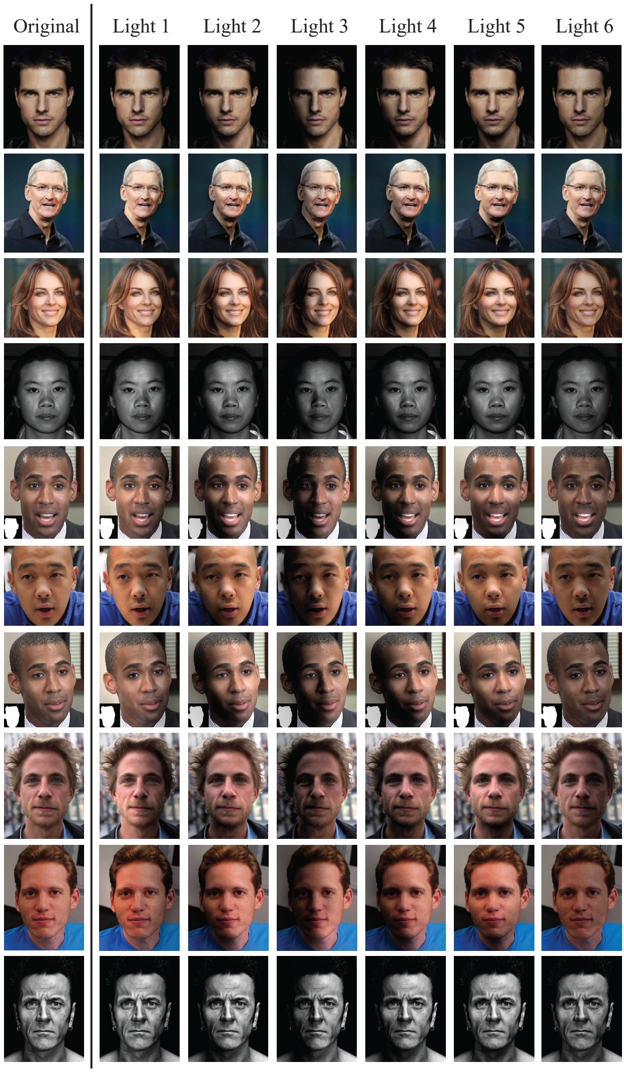


Fig. 3. Relighting Table Part 2. Relighting the image according to several lighting conditions. Each row is one subject, each column is one lighting condition.

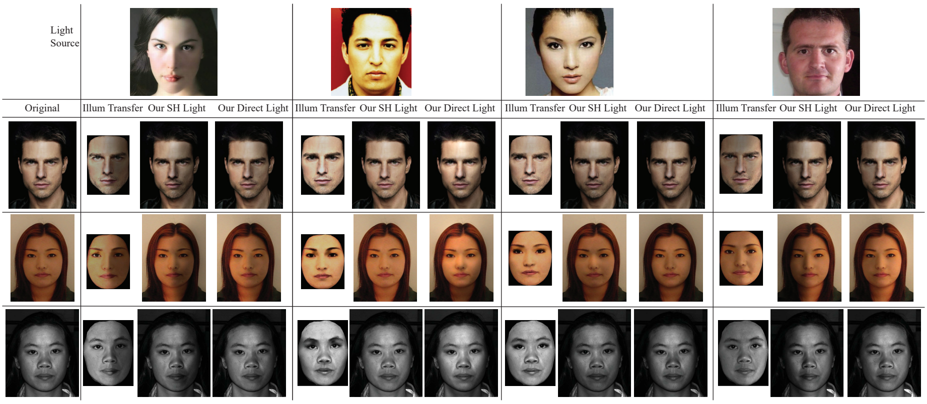


Fig. 4. Full version of Figure 5 in paper. Comparison to the lighting transfer method [3]. In each case, the first image comes from [3] (lighting transfer). The second is our result with a manual choice of spherical harmonic light to match target lighting, and the third is our method with manually choice of directional light to match target lighting.

Fig. 5. Full version of Figure 4 in paper. Baseline rendering methods compared to ours. Note that removing the detail map produces overly smooth faces, and using multiplicative detail loses detail in dark or bright areas.

Fig. 6. Comparison of simulating scatter effects by smoothing shading and no smoothing. Smoothing shading field makes the results more natural.

Fig. 7. Relighted makeup transfers from reference (lower right inset) image to input (lower left inset) image, for both genders *Best viewed at high resolution, in color.* Further examples.

Fig. 8. Across gender transfers are usually successful. *Best viewed at high resolution, in color.* Further examples.

Fig. 9. One reference transferred to multiple inputs. The input retains their face shape, but appears to wear the reference's makeup. *Best viewed at high resolution, in color.* Further examples.

Fig. 10. Multiple references transferred to one input. The input retains their face shape, but appears to wear the reference's makeup. *Best viewed at high resolution, in color.* Further examples.

Fig. 11. Transfer makeup to women. References in first row and inputs in first column.

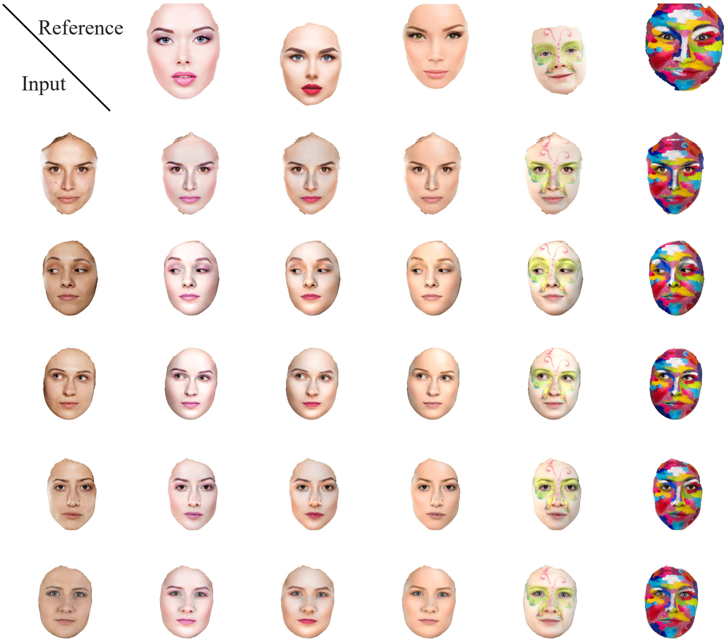


Fig. 12. Transfer makeup to women, with face mask. References in first row and inputs in first column.

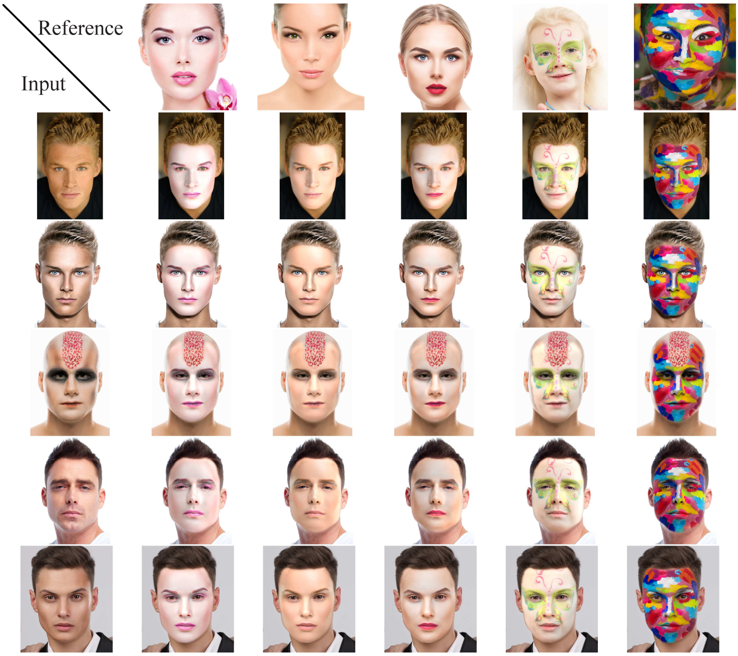


Fig. 13. Transfer makeup to men. References in first row and inputs in first column.

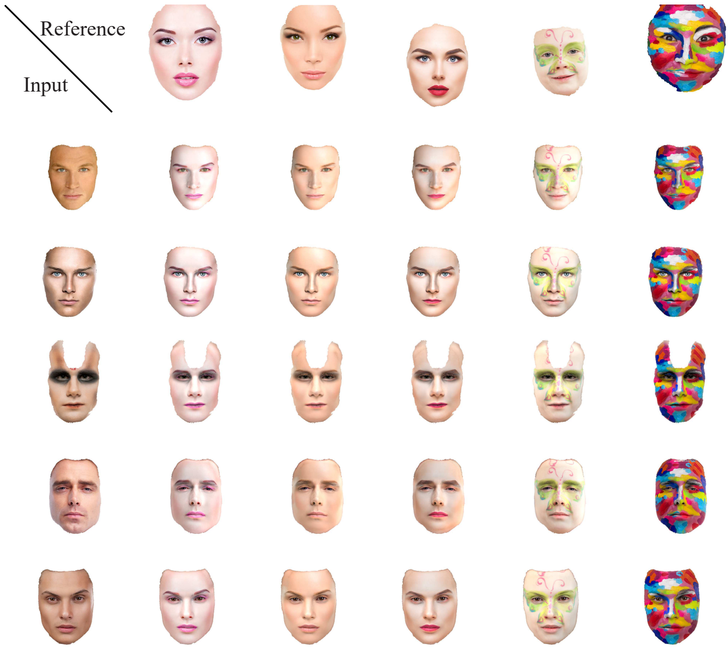


Fig. 14. Transfer makeup to men, with face mask. References in first row and inputs in first column.

Fig. 15. Transfer no makeup to no makeup face. References in first row and inputs in first column.

Fig. 16. Transfer no makeup to no makeup face, with face mask. References in first row and inputs in first column.

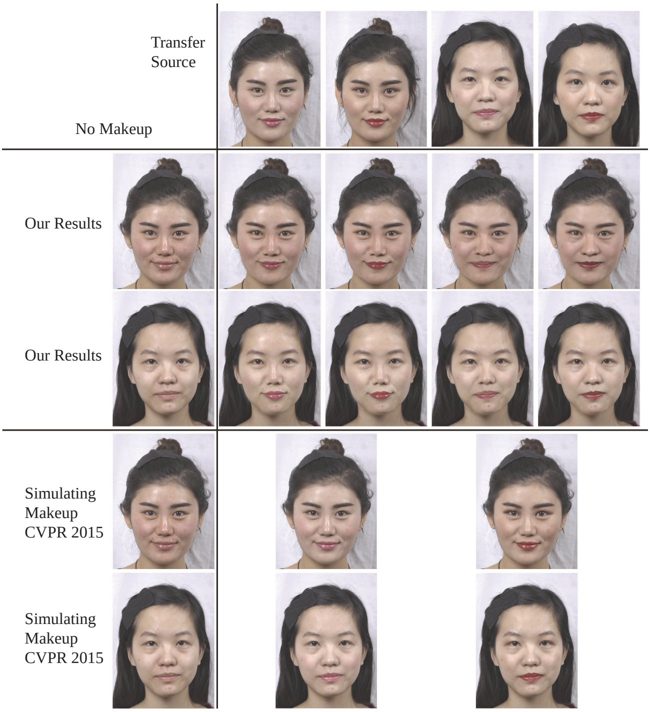


Fig. 17. Here are two makeup adjustment results. Our method transfers makeup from the first row to the first column, while Simulating Makeup [4] uses physical model to simulate makeup. Results of our method are based on source images, and results of [4] are based on parameters. This makes it hard to do a fair comparison, but the lips of our results are more real.

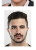
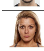
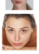
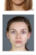
		Age	Attractive	 24, 3	 21, 6	 23, 6	 25, 6	 21, 6	 24, 5	 21, 3	 22, 2	 35, 2	 19, 3
	22, 4	22 → 20	4 → 6	2, 1	-2, 1	-1, 1	0, 1	-2, 1	0, 2	0, 0	4, 0	NaN, NaN	0, 0
	21, 5	21 → 21	5 → 5	2, 0	0, 0	0, -1	0, 0	0, -1	0, 0	0, 0	4, -1	NaN, NaN	1, -1
	33, 3	33 → 23	3 → 4	-4, 0	-10, 0	-5, 0	-4, 0	-4, -1	-7, -1	-4, 0	NaN, NaN	Nan, NaN	-4, -1
	24, 5	24 → 22	5 → 6	1, 0	-2, 0	1, 0	1, 1	-2, 0	-1, 1	0, -1	2, -2	4, -3	0, -2
	27, 4	27 → 22	4 → 4	-2, 0	-5, 0	-4, 0	-3, 0	-4, -1	-5, 0	-4, 0	3, -1	5, -1	-3, -2
	26, 3	26 → 21	3 → 5	-3, 1	-5, 1	-2, 1	-3, 2	-4, 2	-3, 2	-4, 1	8, -1	3, -1	-3, 0
	24, 4	24 → 22	4 → 6	-1, 0	-2, 1	-1, 1	-1, 2	-1, 1	-2, 2	-2, -1	0, -2	7, -2	0, 0
	19, 4	19 → 19	4 → 4	1, -2	0, 0	0, -1	1, -1	1, -1	0, 0	0, -1	1, -2	NaN, NaN	3, -1
	21, 3	21 → 20	3 → 5	1, 0	-1, 2	2, -1	1, 0	1, -1	1, 0	0, 0	2, -2	7, -1	2, -1
	22, 4	22 → 20	4 → 6	NaN, NaN	NaN, NaN	-1, 0	-1, 1	-2, 1	-2, 2	-1, -1	2, -1	NaN, NaN	-1, 0
	22, 3	22 → 20	3 → 4	-1, -1	-2, 0	-1, -1	-1, 0	0, 0	-2, 1	-2, -1	3, -1	8, -1	-2, -1
	26, 2	26 → 23	2 → 3	-1, 0	-3, 1	-1, 0	0, 0	1, -1	-1, 0	-3, 0	0, -1	NaN, NaN	4, 0
	24, 1	24 → 21	1 → 3	-1, 1	-3, 1	-2, 1	-2, 1	-1, 1	-2, 2	-1, 1	6, 1	8, 0	0, 1

Table 1. Age and attractive score changes after applying our makeup transfer algorithm. The first row is reference, and the first column is input. The first number in each cell is the age change, positive number means increased age. The second number in each cell is attractiveness change, postive number means increased attractiveness, it's absolute value ranges from 1(least) to 6(most). Number near the image is the absolute age and attactive value of the image. Number in second column is the best improvement from these references in absolute age and attractive value. Number is not available when face detection failed.

Fig. 18. We use detail transfer to transfer the first person's nose to give each target subject the same, rather shiny nose. The first row is the original image, and the second row is the transferred image.

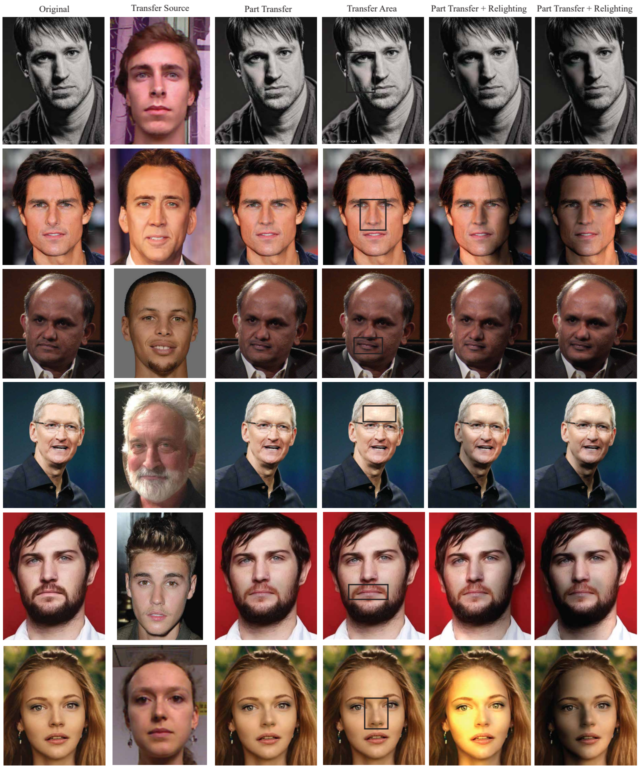


Fig. 19. Full version of Figure 10, one component transfer in paper. We labeled the transfer area in black boxes. In first row, we transfer smooth skin on cheek; in second row, we change the nose shape; in third row, we transfer the mouth; in fourth row, we add wrinkles on the forehead; in fifth row, we color the lip; in last row, we change the nose shape.

Fig. 20. Full version of Figure 10, all components transfer in paper.

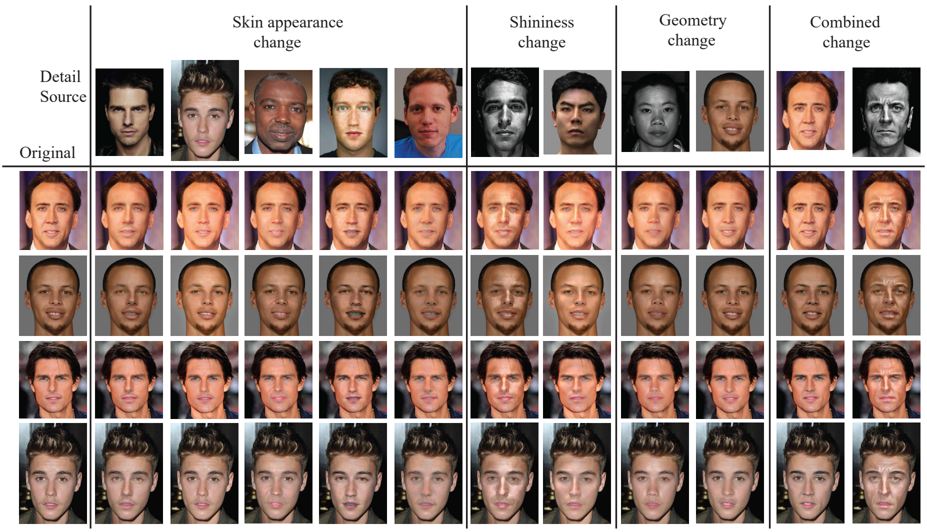


Fig. 21. Transfer Table Part 1. We transfer all of the nine parts of the face detail map (full transfer) from the subjects in the detail source row (first row) to the subjects in the orginal column (first column). Each row is one subject, and each column shares the same face detail map from the detail source person in that column. We grouped the transfer effects into skin property change, shininess change, geometry change and combined change.

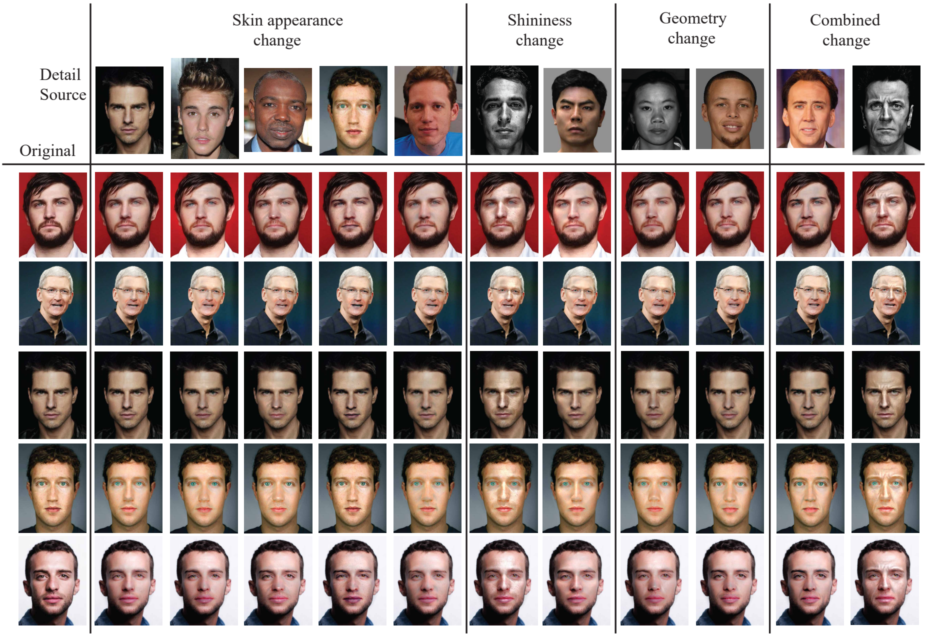


Fig. 22. Transfer Table Part 2. We transfer all of the nine parts of the face detail map (full transfer) from the subjects in the detail source row (first row) to the subjects in the orginal column (first column). Each row is one subject, and each column shares the same face detail map from the detail source person in that column. We grouped the transfer effects into skin property change, shininess change, geometry change and combined change.

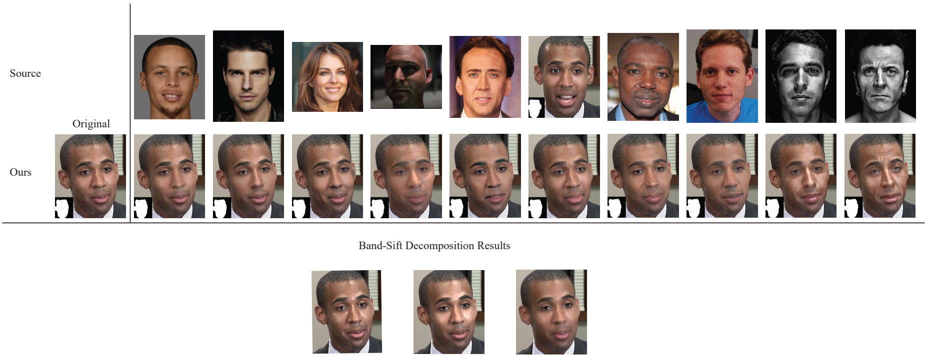


Fig. 23. Transfer Comparison Part 1. We transfer several different subjects' face details to one subject. Ours are our transfer results, source is the face where the detail map comes from. Band-Sift Decomposition images come from [1]. We cannot directly compare with their method, because we aim at different things. The biggest advantage for our transfer method is that we can create various effects, which only depend on source images.

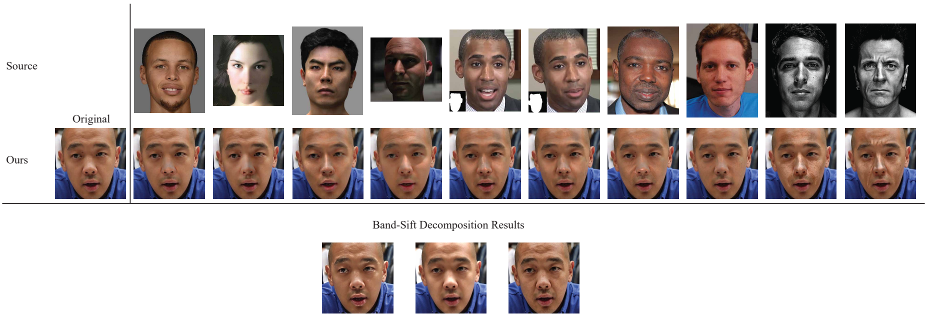


Fig. 24. Transfer Comparison Part 2. We transfer several different subjects' face details to one subject. Ours are our transfer results, source is the face where the detail map comes from. Band-Sift Decomposition images come from [1]. We cannot directly compare with their method, because we aim at different things. The biggest advantage for our transfer method is that we can create various effects, which only depend on source images.

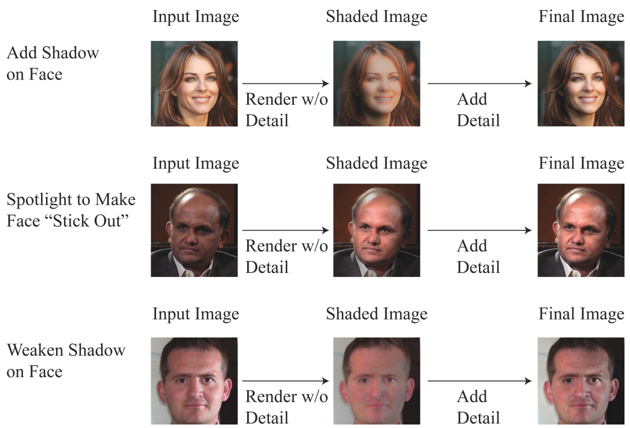


Fig. 25. Relighting based application scenarios. We list three scenearios: add shadow on face, use spotlight to make face "stick out", and weaken shadow on face. For each scenario, we first render the image according to the lighting, and then add the detail map back.

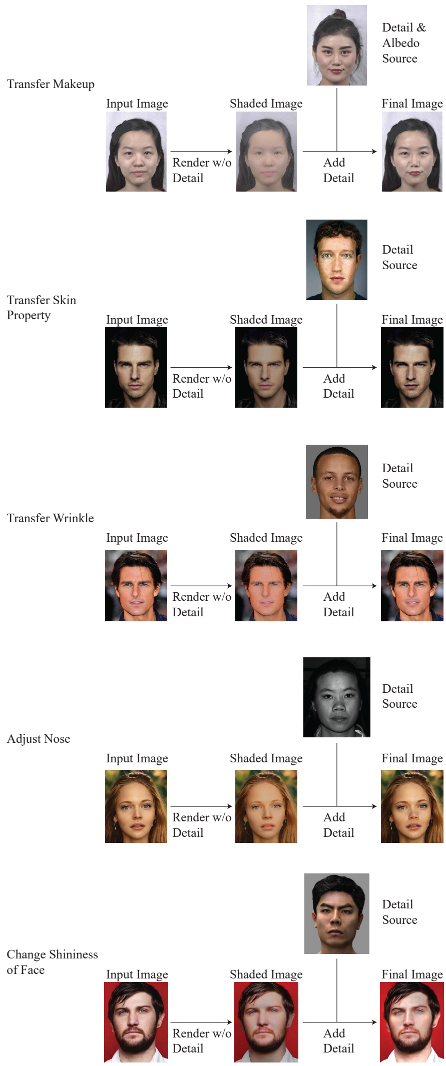


Fig. 26. Transfer based application scenarios. We list five scenarios: transfer makeup, transfer skin property, transfer wrinkle, adjust nose and change shininess of face. For each scenario, we first render the image according to the lighting, and then add back the transferred detail map. The makeup transfer scenario is a little different, refer to Sec. 3.

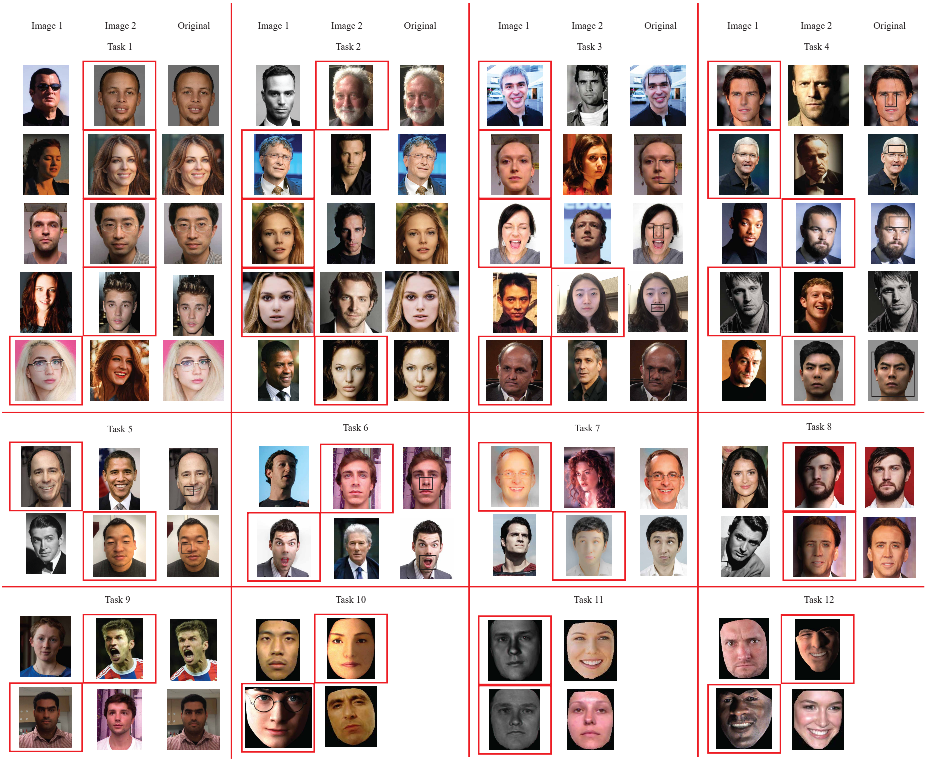


Fig. 27. Our user study images. We have 12 different tasks, refer to Sec. 7. Images are given by pairs (Image 1, Image 2), and the one inside a red box is the edited image. The corresponding original image is the third one. For task 10, 11 and 12, edited images come from their corresponding papers.

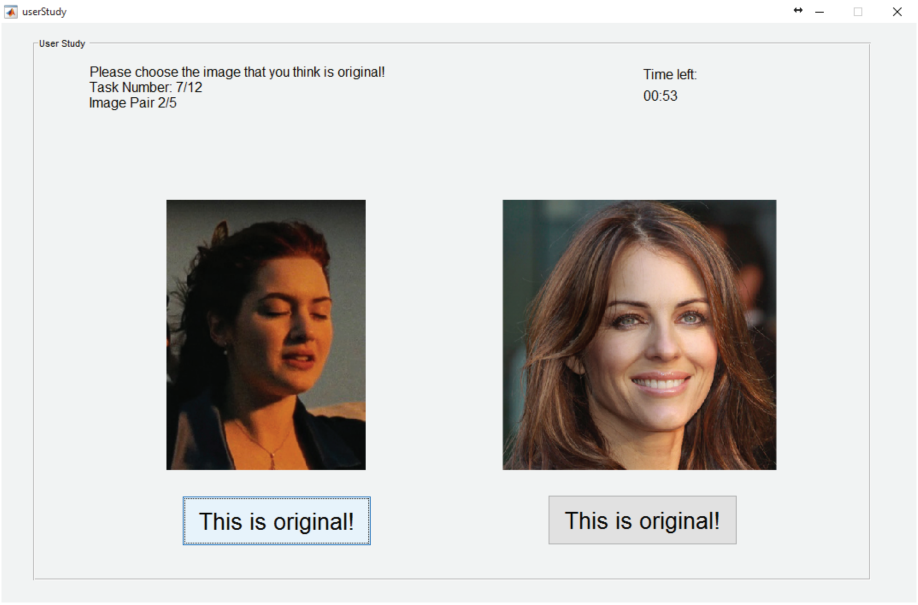


Fig. 28. Our user study interface. Users are told about possible edit operations such as relighting. Tasks appear in random order, and for each image pair, user has 60 seconds to make choice.

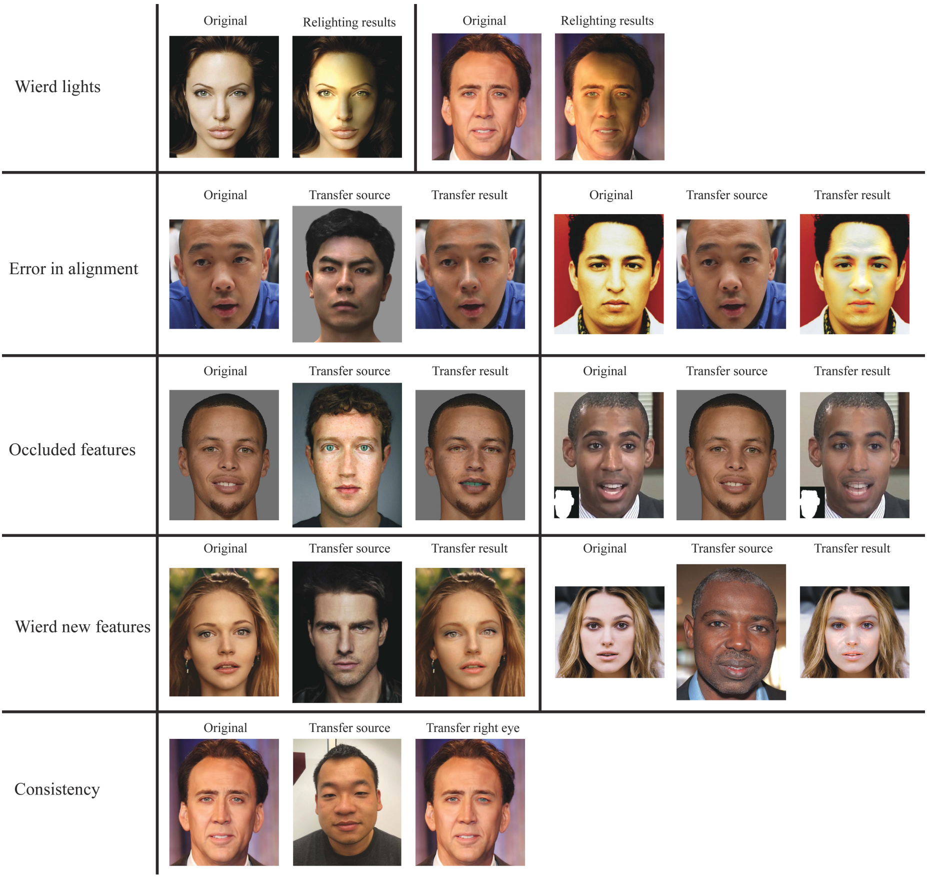


Fig. 29. The failure cases due to the limitation of our current system.

References

1. Boyadzhiev, I., Bala, K., Paris, S., Adelson, E.: Band-sifting decomposition for image-based material editing. ACM Trans. Graph. (2015)
2. Chen, J., Su, G., He, J., Ben, S.: Face image relighting using locally constrained global optimization. In: ECCV, pp. 44–57. Springer (2010)
3. Chen, X., Chen, M., Jin, X., Zha, Q.: Face illumination transfer through edge-preserving filters. CVPR, IEEE Computer Society pp. 281–287 (2011)
4. Li, C., Zhou, K., Lin, S.: Simulating makeup through physics-based manipulation of intrinsic image layers. CVPR (2015)
5. Wang, Y., Zhang, L., Liu, Z., Hua, G., Wen, Z., Zhang, Z., Samaras, D.: Face relighting from a single image under arbitrary unknown lighting conditions. Pattern Analysis and Machine Intelligence, IEEE Transactions on 31(11), 1968–1984 (2009)