Single Image 3D Face Reconstruction

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Motivation

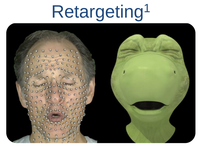
- Image analysis

Face Recognition

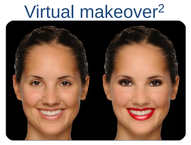
Expression detection

- Face synthesis

Retargeting[1]



Virtual makeover[2]

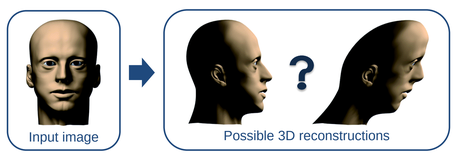


- Why use just a single image?
  - **1.8 Billion** pictures shared everyday in 2014![3] Treasure of images that can be tapped
  - Images are much cheaper to acquire, compared to RGB-D

A good solution should be able to handle various view points, illuminations and effects like cast shadows.

Background

- 3D Reconstruction from single image is ill-posed
- Infinitely many plausible solutions



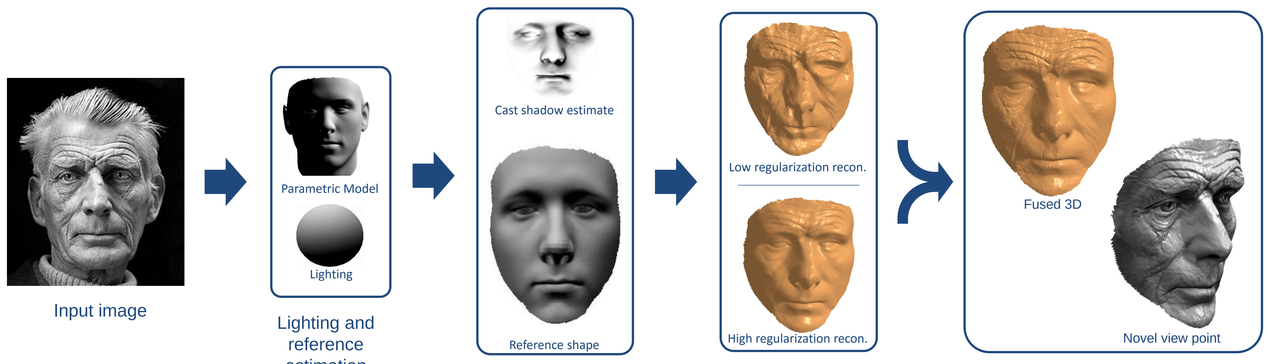
- Broad approaches for constraining the solution:

Reference model[4]

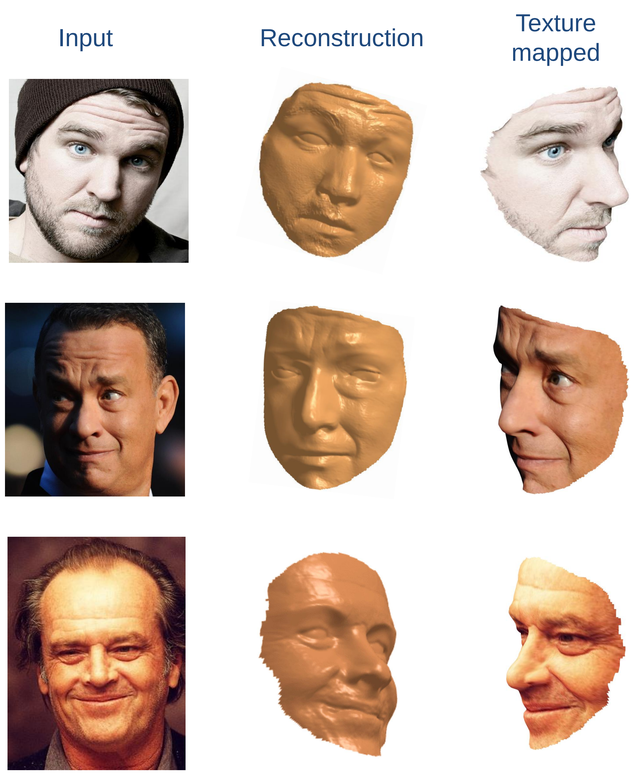
Morphable Model[5]

- We use a combination of the above two
- Cast shadows have mostly been ignored in literature

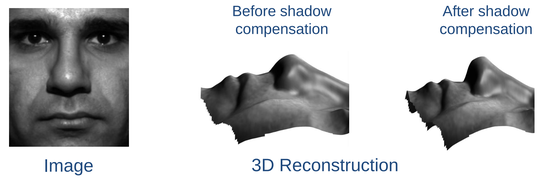
System Pipeline



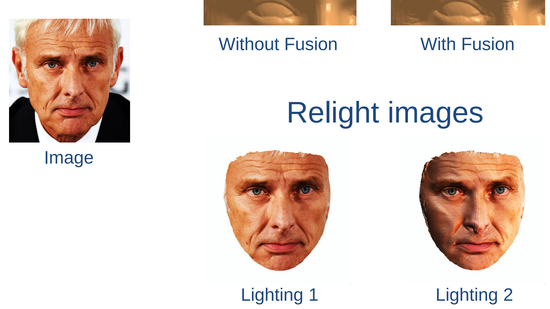
Results



Cast Shadows



Shape Fusion



Relight images

Design Overview

- Fit a parametric reference model to image

- Estimate spherical harmonic lighting coefficients using reference shape and albedo

$$\vec{l} = \frac{I(x,y)}{\rho_{ref}} \vec{Y}_{ref}^{-1}$$

- Predict cast shadows by a PRT system and compensate for them using albedo
- Optimize for shape, penalizing it when its rendering deviates away from input image

$$\min_{shape} \int (I - \rho_{ref} \vec{l} \cdot \vec{Y}(\vec{n}))^2 + \lambda_1 (\triangle G * d_z) + \lambda_2 d_z$$

- Fuse together reconstructions with different regularization weights to get sharp details

Conclusion

- Cast shadows introduce errors in 3D
- Can be handled by shadow estimation
- Fusion of multiple reconstructions improves output quality
- Fused reconstruction preserves shape as well as crisp details
- Novel applications like face relighting, view-point changing have be shown to give promising results after good reconstruction

References

[1] Kholgade, Natasha, Iain Matthews, and Yaser Sheikh. "Content Retargeting Using Parameter-parallel Facial Layers." *Proceedings of the 2011 ACM SIGGRAPH/Eurographics Symposium on Computer Animation - SCA '11*, 2011.
[2] Mallick, Satya P., Todd Zickler, Peter Belhumeur, and David Kriegman. "Dichromatic Separation." *ACM SIGGRAPH 2006 Sketches on - SIGGRAPH '06*, 2006.
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[4] Kemelmacher-Shlizerman, I., and R. Basri. "3D Face Reconstruction from a Single Image Using a Single Reference Face Shape." *IEEE Transactions on Pattern Analysis and Machine Intelligence IEEE Trans*, 2011.
[5] Blanz, Volker, and Thomas Vetter. "A Morphable Model for the Synthesis of 3D Faces." *Proceedings of the 26th Annual Conference on Computer Graphics and Interactive Techniques - SIGGRAPH '99*, 1999.
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For more information, suggestions and queries
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