

Automatic Face Replacement on a Morphing Model

Han Li

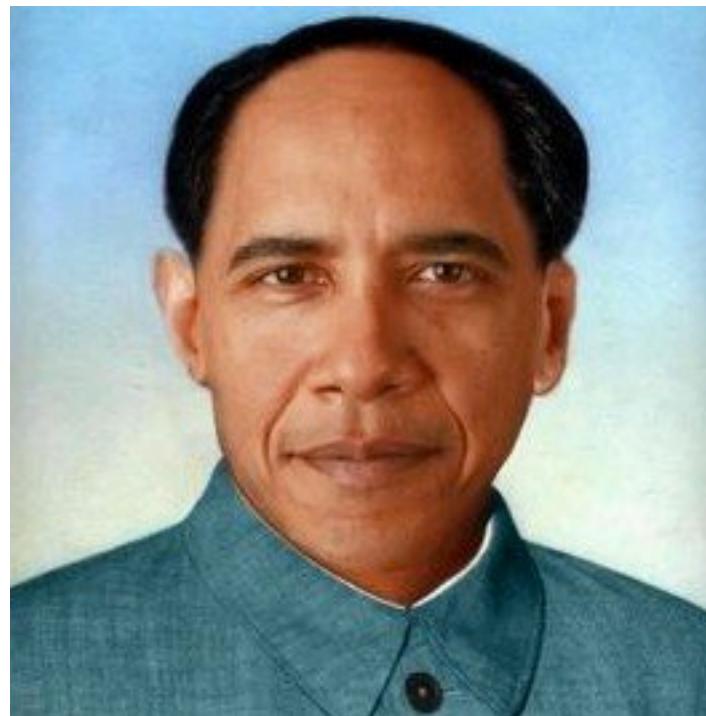
Wentao Wu

Face Replacement

- What?
 - Replace the face(s) in an image with another one
- Why?
 - It's FUNNY!
 - Bigger concern: online privacy
 - Billions of online images/videos: Google Street View, YouTube videos
 - People might not consent to be photographed
 - Normal way: Mosaic, looks UGLY!
 - Better solution: change the face(s) with a synthesized one

Face Replacement

- Our goal
 - Propose a FAST way for AUTOMATIC face replacement such that the result image looks NATURAL to human judgments

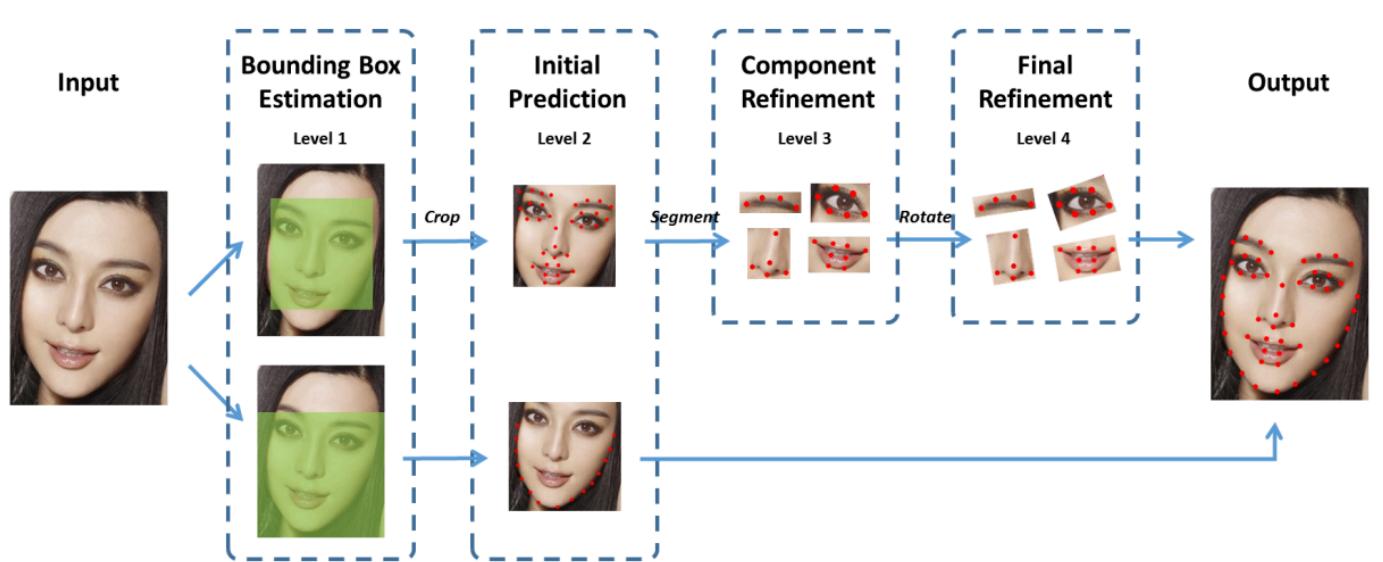
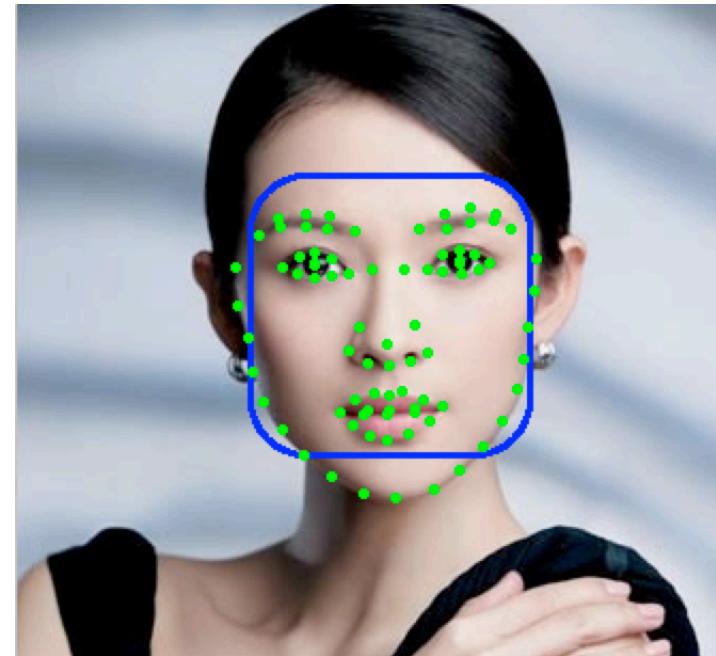


Pipeline

- Basic idea
 - Shape-morphing-based model
- Four steps
 - Landmark localization (face detection)
 - Face morphing based on TPS
 - Optimal seam searching
 - Blending

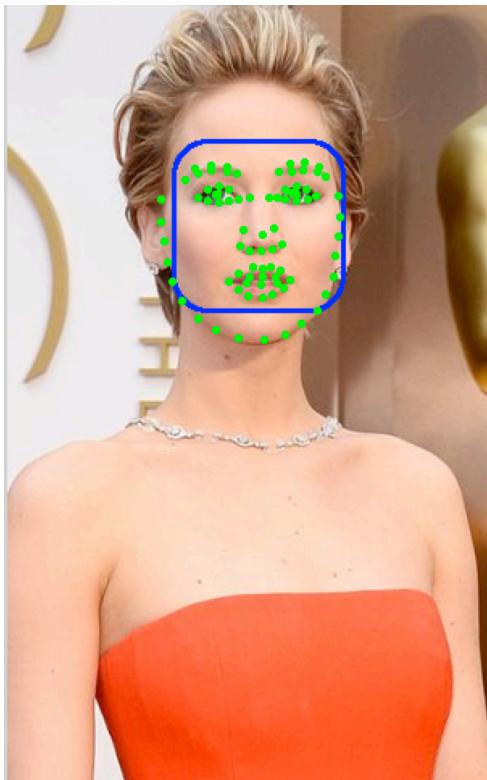
Landmark localization

- Face ++
 - Deep Convolutional NN approach
 - 83 landmarks
 - State-of-the-art performance

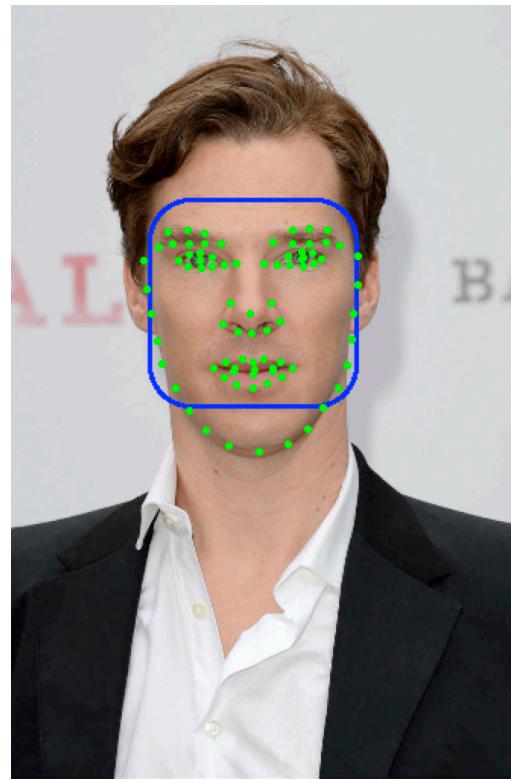


Landmark localization

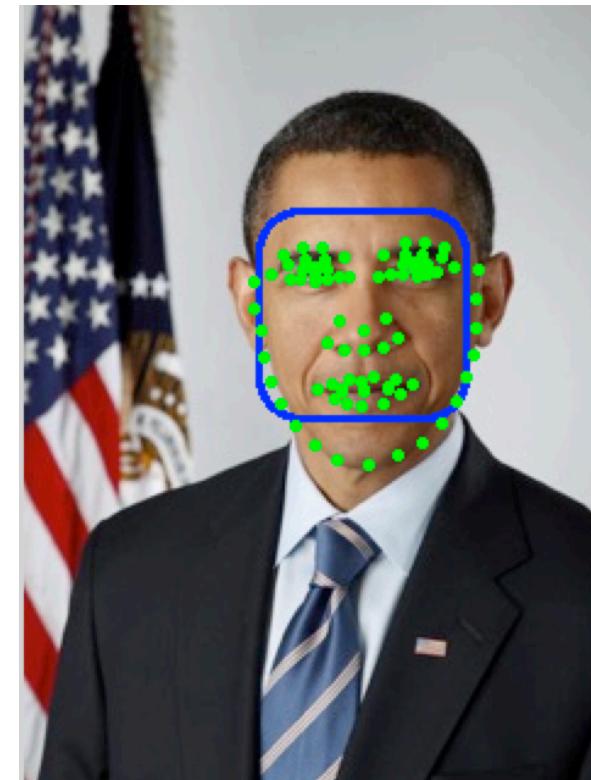
- More examples



Jennifer Lawrence



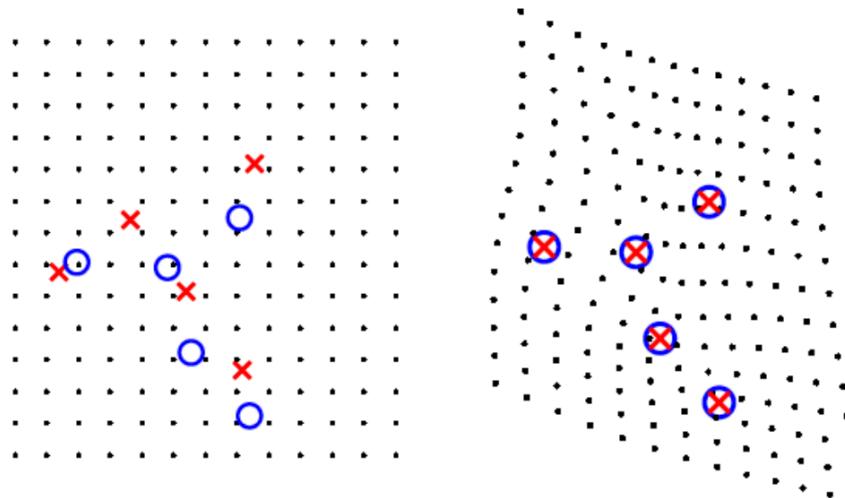
Benedict Cumberbatch



Barack Obama

Face Morphing

- Can't just use the convex hull for replacement
 - Artificial !!
- **Thin Plate Spline**
 - Interpolation method for **non-rigid** surface warping
 - Perfect points alignment with smoothed surface deformation
 - e.g. move the red points to the blue ones



Face Morphing

- Fit the parameters: w, a
 - $U(r) = -r^2 \log(r^2)$
 - Ps are the source points to be aligned
 - Vs are the target values on one axis

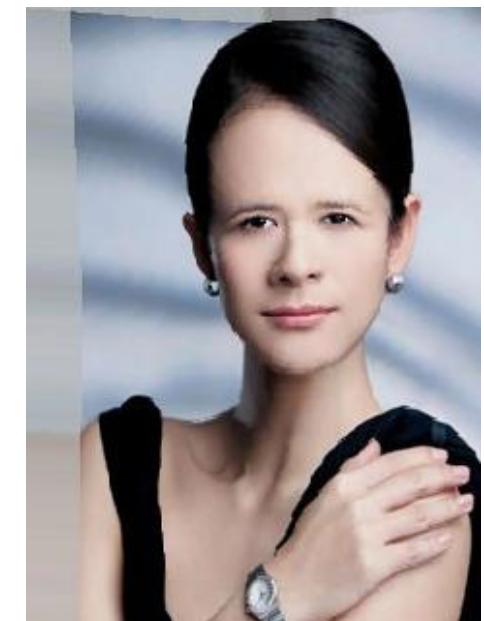
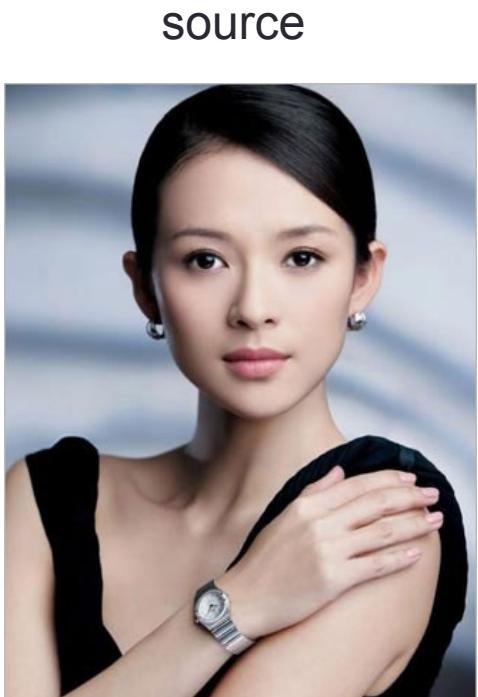
$$\begin{bmatrix} K & P \\ P^T & O \end{bmatrix} \begin{bmatrix} w \\ a \end{bmatrix} = \begin{bmatrix} v \\ o \end{bmatrix}$$

$$K_{ij} = U(\|(x_i, y_i) - (x_j, y_j)\|)$$

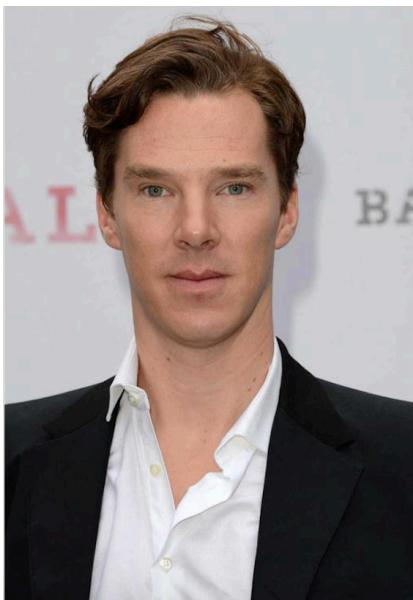
- Fit a model for EVERY coordinate axis!

Face Morphing

- Align the source landmarks to the target ones

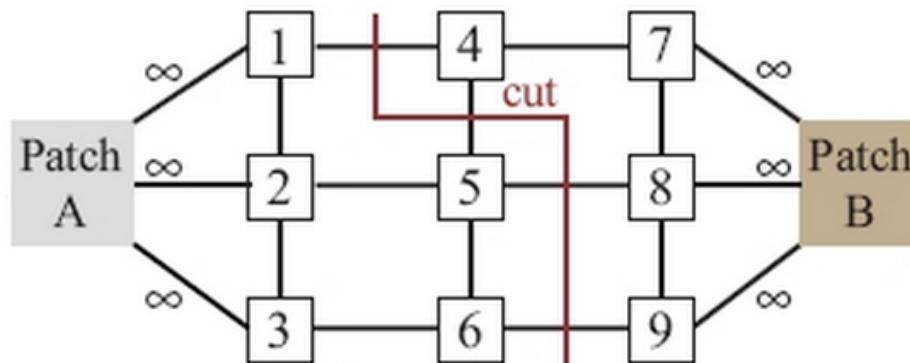


Face Morphing



Optimal Seam Search

- Combine two faces
 - Find a seam s.t. minimum difference between them
- Graph-cut Algorithm
 - Formulate the image as a connected graph
 - max-flow/min-cut problem



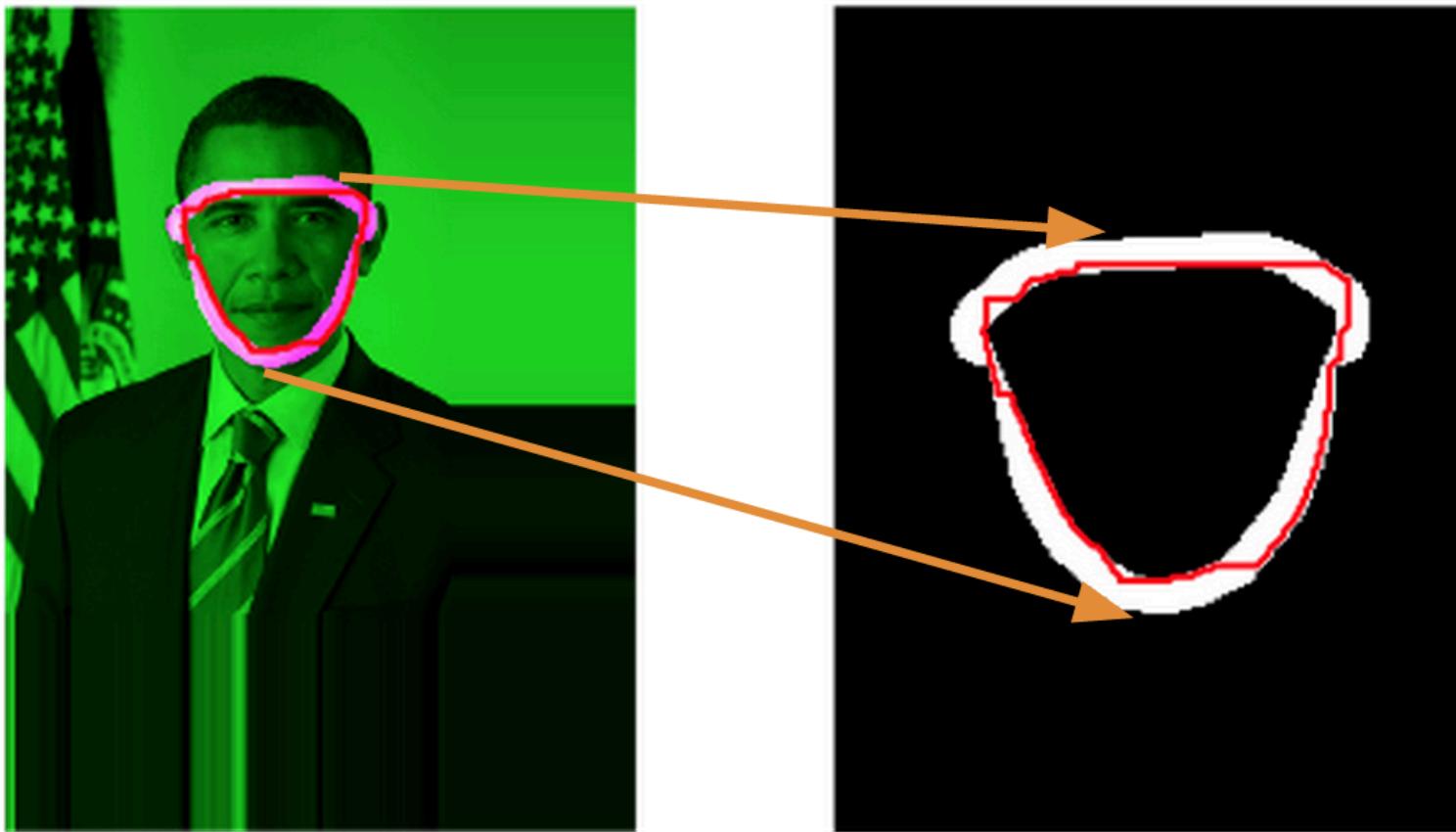
Optimal Seam Search

- Mask



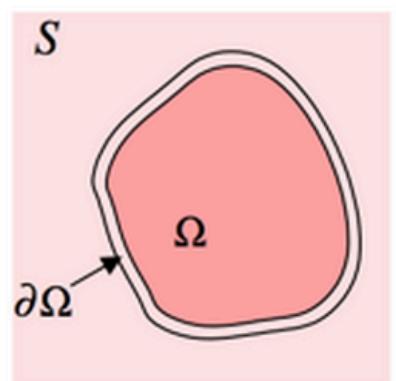
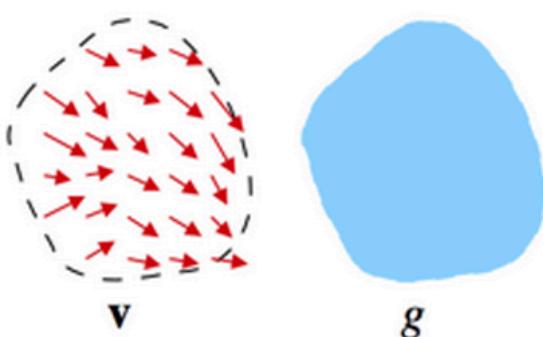
Optimal Seam Search

- Result



Blending

- Blend two faces
 - Dissolve the boundaries
 - Adjust color
- Poisson Blending
 - Compose two images in gradient domain



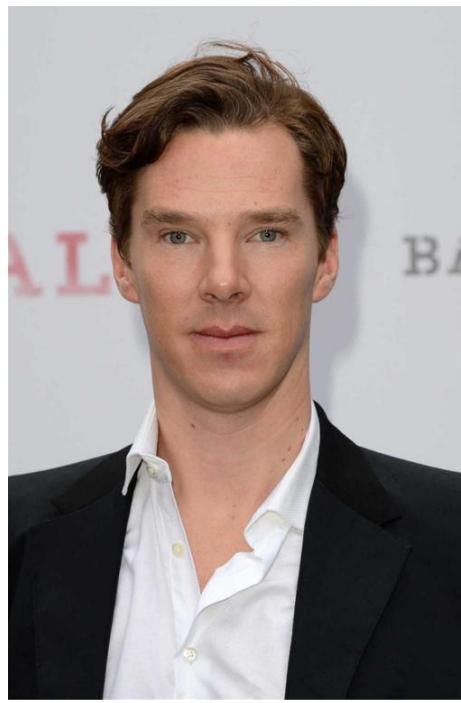
v – Gradient of a region in an image
g – Selected region of source
 f^* – Known functions that exist in domain S
 f – Unknown functions that exist in domain Ω
 Ω – Region g that is now placed on domain S
 $\partial\Omega$ – Boundaries between the source and target regions

Blending

- Result



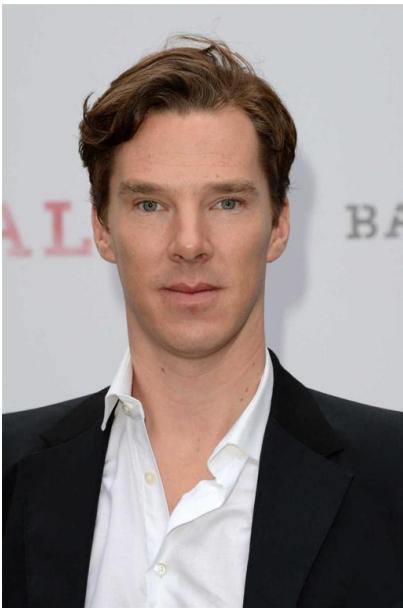
More Results



More Results



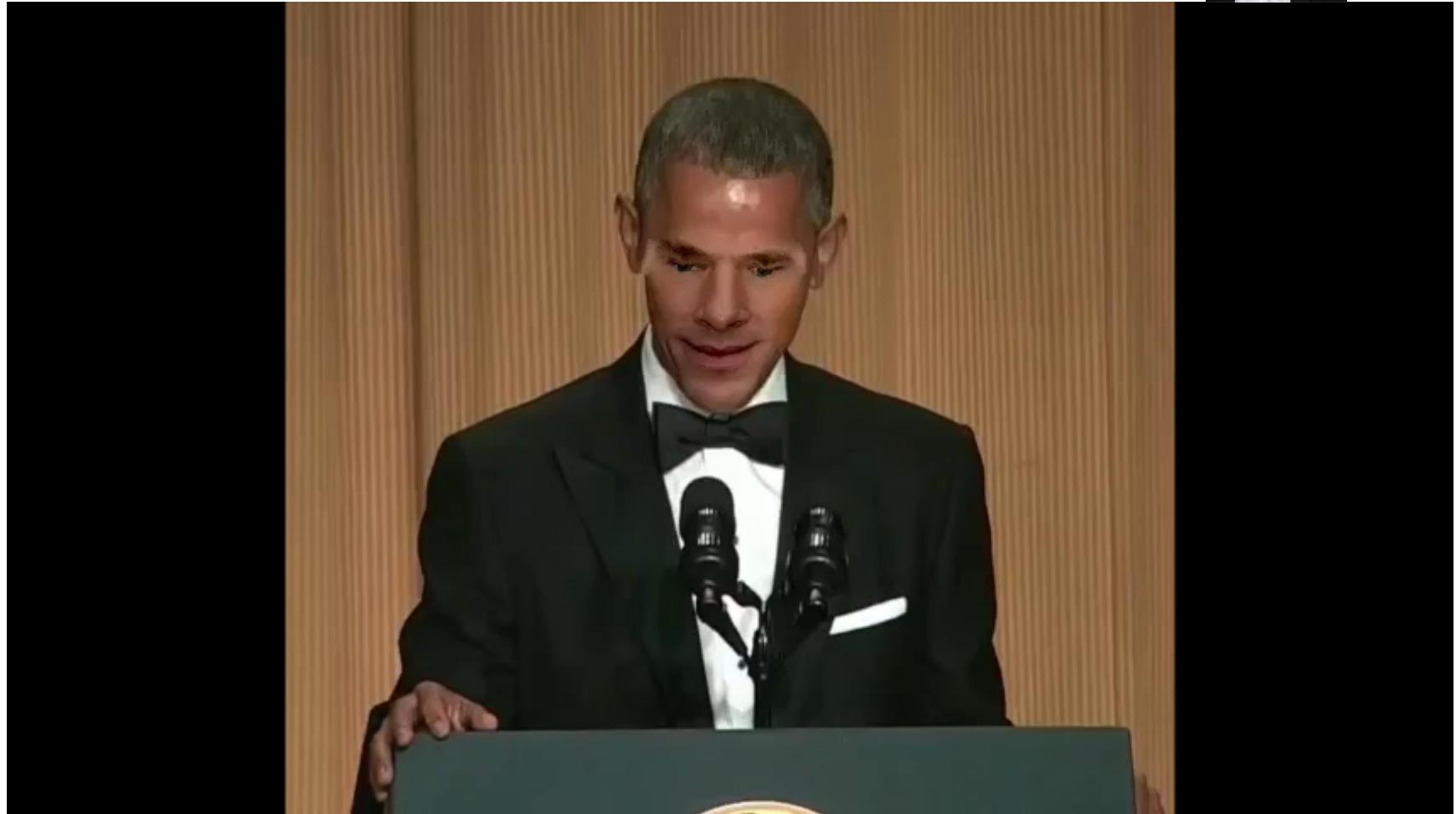
More Results



Video Face Replacement



Video Face Replacement



Summary & Future Work

- Good at dealing with front face
- Bad with side face
- Need better color adjustment
- Discontinuous video frames
 - Difficult to detect landmarks, especially for side faces
 - Possible solution: landmark interpolation between frames
- Improve speed
 - About 15s per frame

Thank you!