CS180 Project 3: Face Morphing

By Ethan Kuo

Introduction

Face morphing is a technique used to transform one face into another. It involves blending the shape and appearance (texture) of two faces. In this project, we first morph one face into another through a gradual sequence. Then, we compute "average faces" for a population. Finally, we build a caricature by extrapolating features.

Building a Morph Sequence

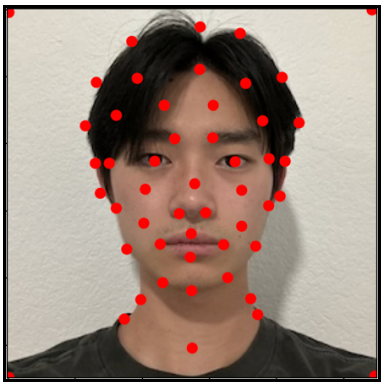
Part 1: Defining Correspondances

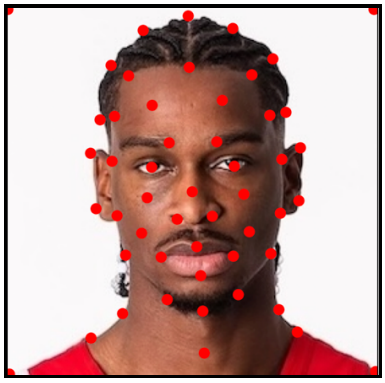
Suppose we want to morph these two faces: me and my favorite basketball player.


Ethan Kuo

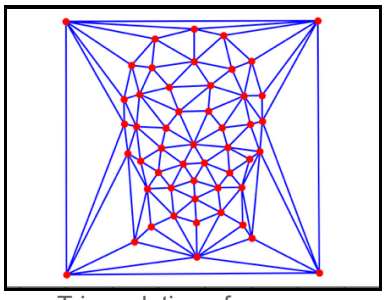

Shai Gilgeous-Alexander

First, choose key points on both images that correspond to each other. Here, I do this manually. Note that each point uniquely coresponds to another point in the other image.


Ethan Kuo with key points

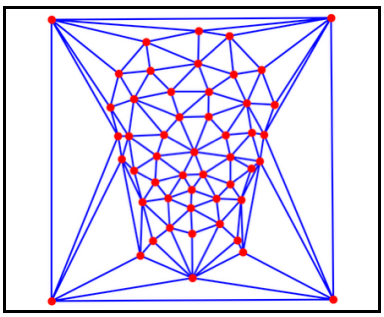

Shai Gilgeous-Alexander with key points

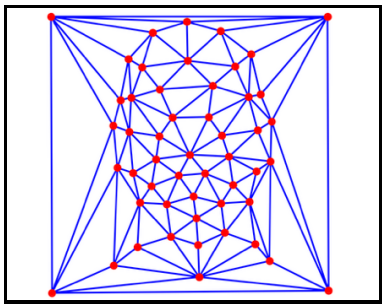
We then find the midpoints of each corresponding pair of key points to arrive at an average geometry. Essentially, this captures the average facial structure of the images. We then run the **Delaunay triangulation algorithm** on this average geometry to produce many triangles.


Triangulation of average geometry

Part 2: Computing the Midway Face

Why triangles? Because we can build a midway image from the average geometry, triangle by triangle. Note that this triangulation that was computed on the average geomtry can be mapped to each image. The high level idea is that for each triangle in the average geometry, we color that triangle by combining the colors in the corresponding triangles in each image.


Triangulation of Ethan Kuo


Triangulation of Shai Gilgeous-Alexander

More precisely, we will use **inverse warping**, which involves computing an affine transformation matrix that maps a triangle in the target geometry to the corresponding triangle in the source geometry. Then, we apply this matrix to each coordinate within the target triangle to get a corresponding pixel within the source triangle. Since this is a linear transformation, the preimage is not guaranteed to be an integer coordinate, so I used **bilinear interpolation** to assign a color to non-integer coordinates using its neighbors. Now each pixel has a preimage in both images, we simply take the average RGB pixel value as its color.

Conceptually, I like to think of inverse warping as a way to peer into a source image and bring color into the target image.

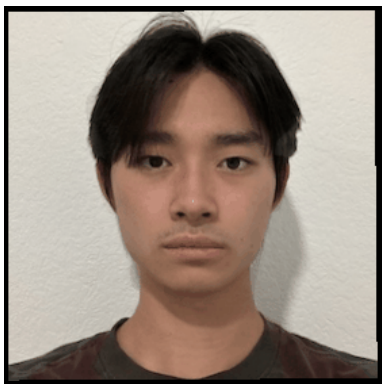

Ethan Kuo


Midway face


Shai Gilgeous-Alexander

Part 3: The Morph Sequence

Note for the midway face, we took the average of the geometries and the colors. We can generalize this using weighted averages to create intermediate faces. Combining them all, we arrive at a morph sequence!


Morph sequence

Here are some more morph sequences I created!


Tzuyu

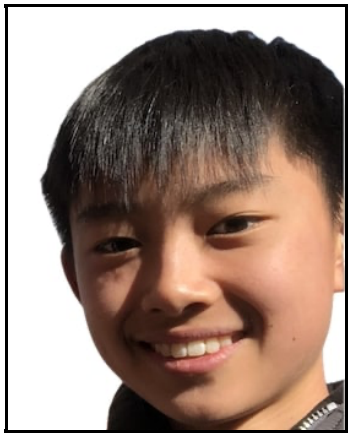

Morph sequence

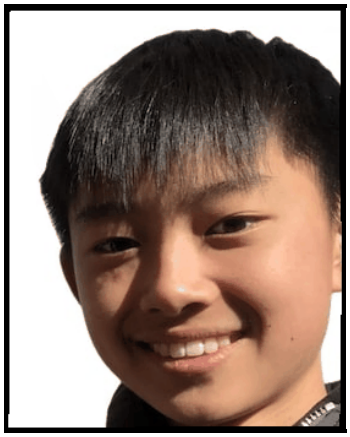

Minjoo


Lia


Morph sequence


Julie

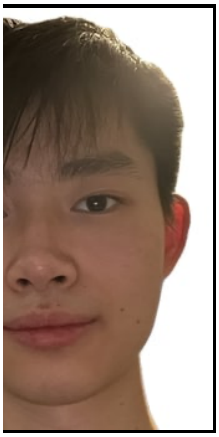

Young Ethan


Morph sequence


Current Ethan

[Bells and Whistles] Themed morphing video

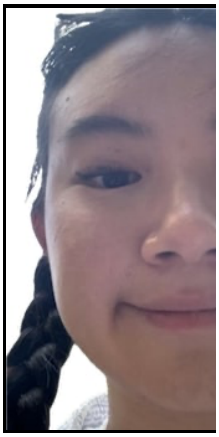
Here, I made a morph sequence between all 5 members of my family! The idea is similar to a 2-face morph, except I defined and triangulated separate correspondances for each adjacent pair of images, essentially stringing 4 morph sequences together.

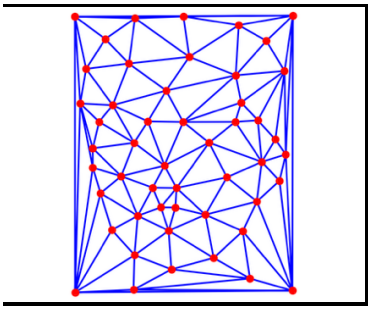

Ethan

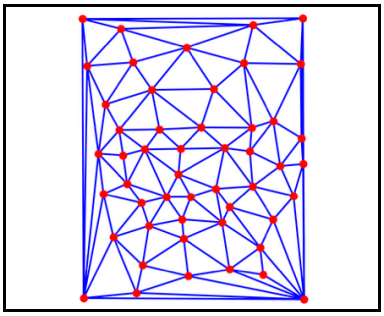

Ehong

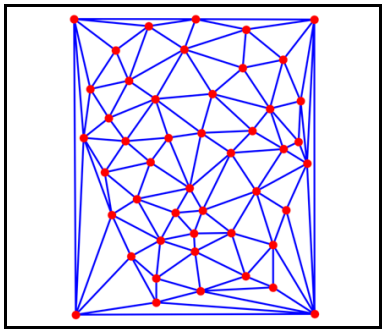

Dad

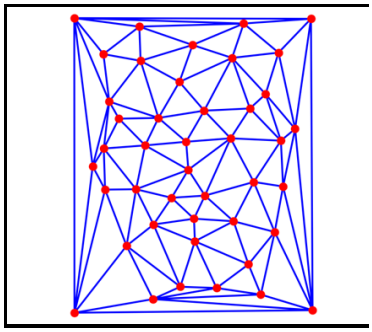

Mom


Ejean


Triangulation for Ethan-Ehong


Triangulation for Ehong-Dad


Triangulation for Dad-Mom


Triangulation for Mom-Ejean


Morph sequence

Mean Faces

Part 4: The Average Brazilian Face

Using the FEI dataset, which consists of 400 faces of Brazilian people, we can compute an average face. This actually involves 2 averages: the average geometry, and the average texture. The average geometry is simply the sum of all geometries divided by the count. Then we bring textureinto the mean geometry through inverse warping,

equally combining pixel intensities from every face.


Mean neutral face


Mean happy face

Here are examples of faces morphed into mean geometries.


Original face


Morphed into neutral


Original face


Morphed into neutral


Original face

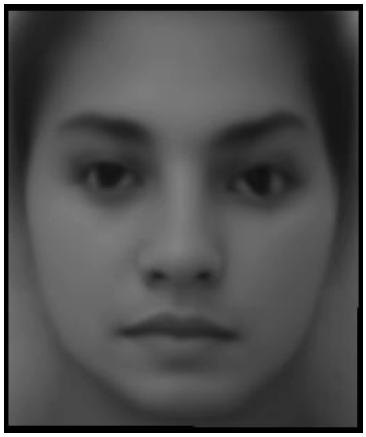

Morphed into happy


Original face


Morphed into happy

For fun, I morphed myself into the average Brazilian neutral face geometry, and vice versa.


Ethan morphed into neutral

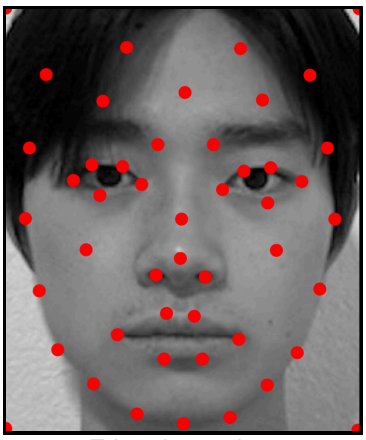

Neutral face morphed into Ethan

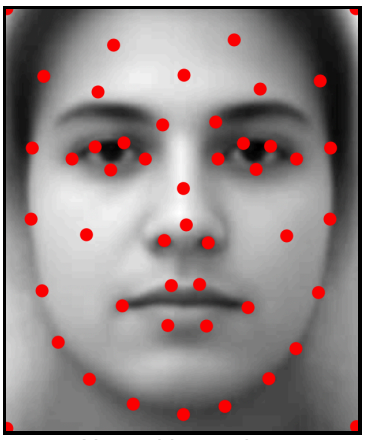
Part 5: Caricature

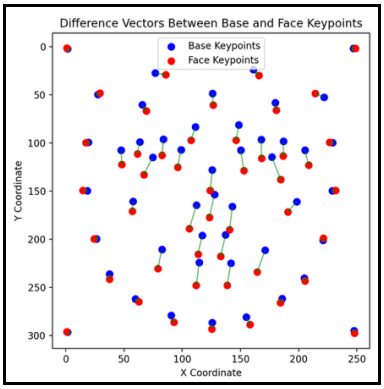
So far, we've only been interpolating between faces, or finding some intermediate between the two. We can also exterpolate between faces to accentuate unique features.

Here, I wanted to emphasize my own facial features relative to the average neutral face. Treating the correspondences selected on my face as some vector `p` and the correspondences on the average expression face as some vector `q`, I calculated `p + α(p - q)` as the target correspondences, computed the extrapolated triangulation, and then warped my face to these targets.

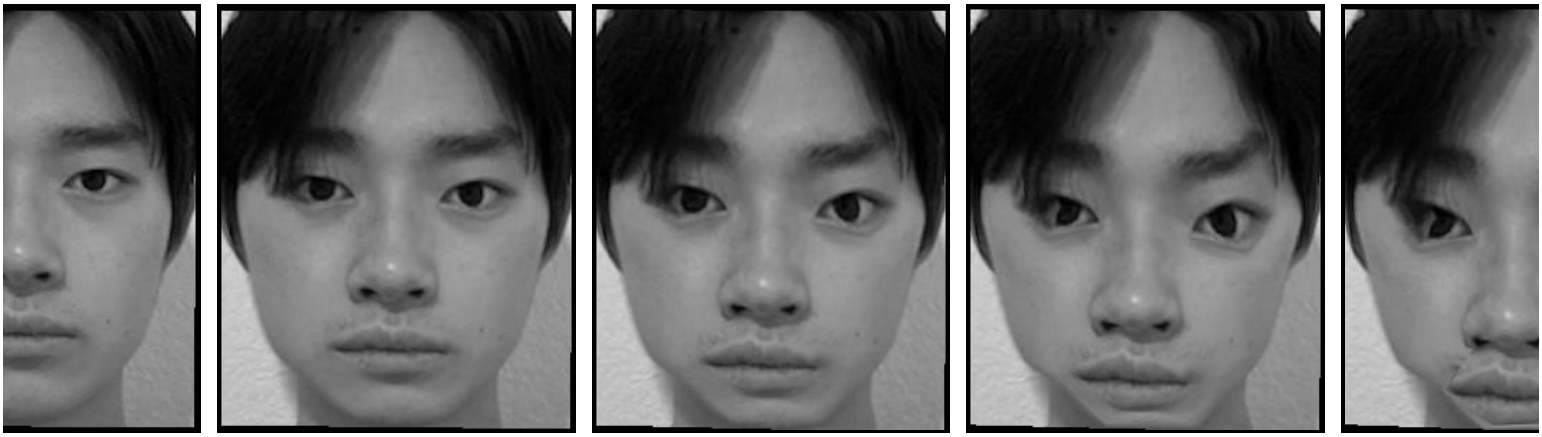
Intuitively, `(p-q)` is a bunch of difference vectors that each capture how much a feature deviates from the mean. When we add some multiple of these vectors back into the image, we emphasize these deviations.


Ethan key points


Neutral key points



Difference vectors



ι = 0 α = 0.5 α = 1 α = 1.5 α = 2

Here, you can see my unique features like a low nose and pointed eyes being exaggerated!