ENSC 474

Assignment 8: *Non-rigid Registration*

Cyrus WaChong

301306459

Using the cpselect tool, 7 landmarks were chosen across the smiling and non smiling images. 7 seemed to be a perfect amount, as more made minimal difference to the image, while making the convolution more complicated and any less caused non-ideal outputs. For u(x), a gaussian function was applied at each point, and at each point, the summation of all the influences of each landmark were added.

$$u(x) = \sum_{i=1}^{7} e^{\frac{-|x-Pi|^2}{2\sigma^2}} u(P_i)$$

This, when mapped, produced the following quiver plot.

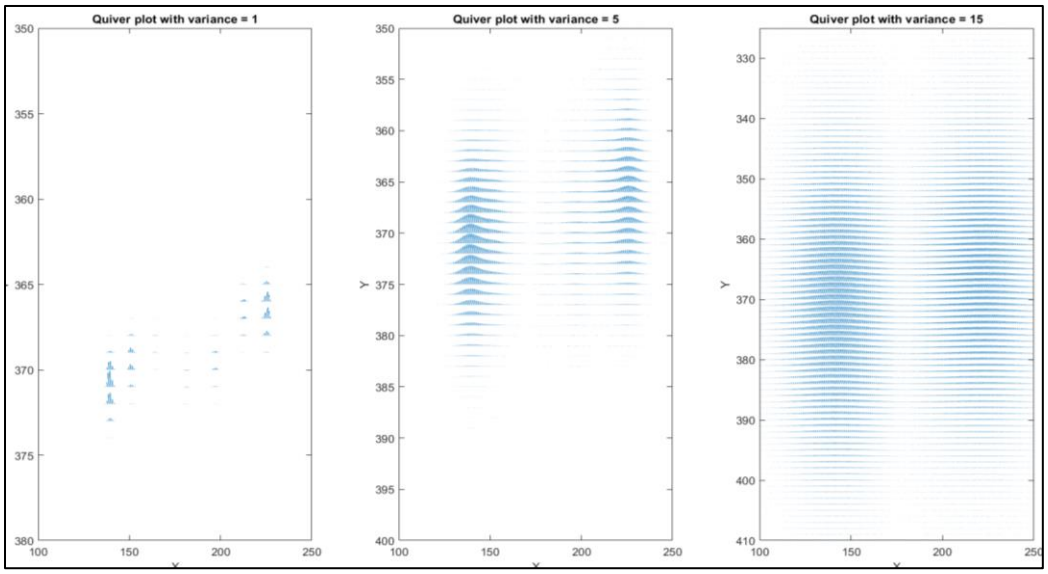

Figure 1: Quiver plot of u(x) for the smile image zoomed in to see the arrows.

The following step was to use find φ(x) and $\varphi^{-1}(x)$, which were found by adding the displacement of u(x) to every point. This resulted in the following output:

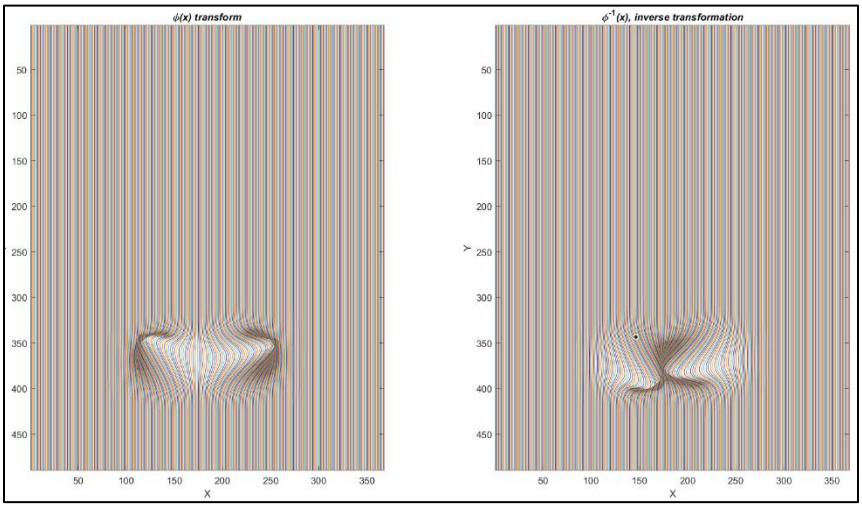

Figure 2: Quiver plot of ϕ(x) and $\phi^{-1}(x)$

For the figure above, the forward function is the function that will be used to create the smile image from the template. The reverse function is what will be used to attempt to recreate the template image.

Many values of variance were tested for the image, where anything below 1 made almost no difference to the image, while anything above 30 was excessively large, causing the output to not be ideal. The images below were done using a value of 15 for variance. The origin was chosen to be at the top left corner, as that is where the value of rows and columns is at its minimum.

Using these transforms, we then applied the $\varphi(x)$ value to the template image to get the target image and the $\varphi^{-1}(x)$ function was applied to the target to return the template. As one expects, this is not perfect when only using 7 landmarks, and causes an incredibly distorted image, that only slightly resembles the wanted output. Below the outputs can be found:

Figure 3: Template image converted to smiling image

The inverse transform was applied to the smile image to turn it into a frown. This result was not as good as the non-smile to smile. It distorted the smile, and did get rid of the smile, but caused odd error points unlike the prior figure. This was tested with many different landmarks, and different number of landmarks, but the result was never satisfactory.

Figure 4: Target image transformed into template image

For this part of the lab, we used landmarks on the template image to create a transfer function for a frowning image. This meant landmarks around the mouth had to be added, that were not on the lips, which was initially assumed to add error, but was necessary for an exaggerated output.

u(x) was calculated, which allowed us to calculate the transfer function. The following figures show the transfer function φ(x) and $\varphi^{-1}(x)$ that were calculated, and the quiver plot of u(x):

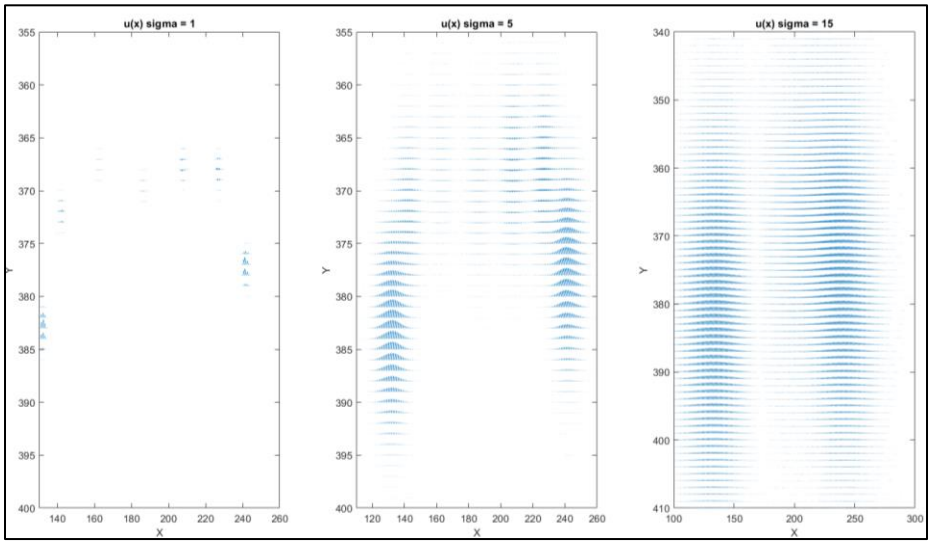

Figure 5: Quiver plot for the u(x) function

The same values of sigma were tested with this version of the u(x), and this gave functions that formed the shape of a frown, which was what was wanted. Below you can see the function applied to a grid, where for this case the inverse function is what will produce the frown on the template image and the forward function will turn a frown into the template. The latter was not done in this lab.

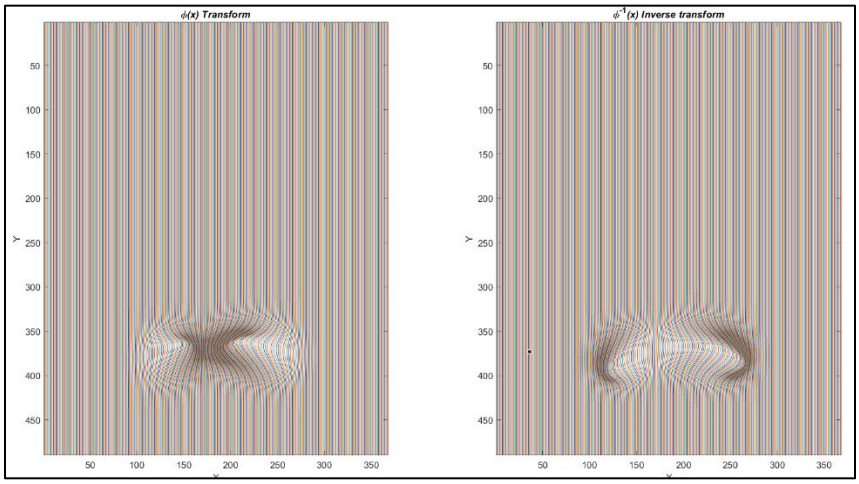

Figure 6: ϕ(x) transfer function for the image

Using these transfer functions, we were able to manipulate the template image and turn it into a frown image. The following figure shows the output.

Figure 7: Template image transformed into frown image

As explained above, the forward transfer function was not used, since only the transformed template image was requested.

Since the GIF does not play in a pdf document, an extra display with 6 images was created to see the progress, which can be seen below. The actual GIF can be found in the “Output files” folder to see the result.

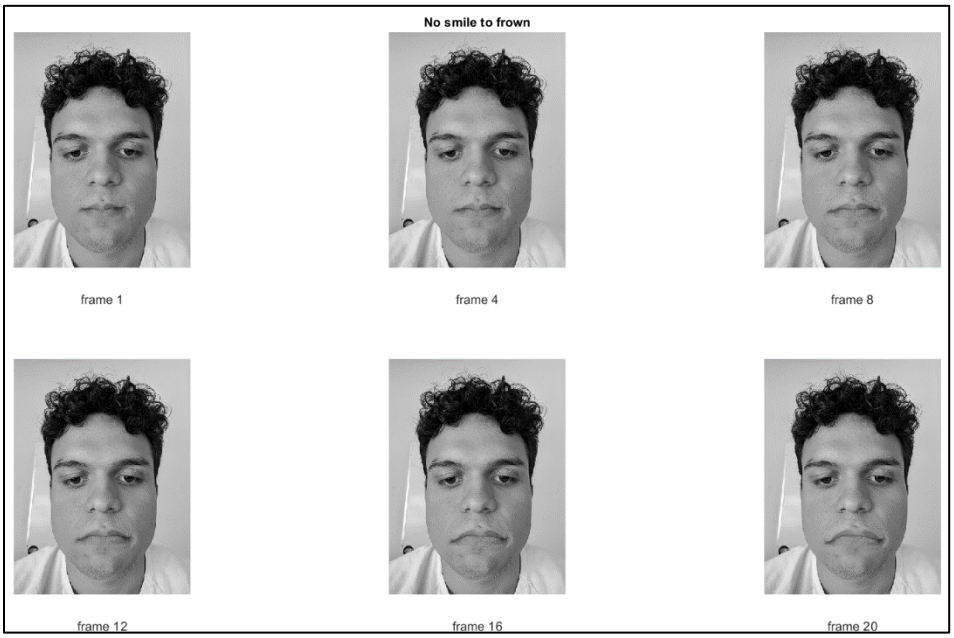

Figure 8: 6 displays to show progress of the GIF

For this lab, the importance of landmark positions, and number of landmarks was very apparent. This is where Faisal's mentality of "good enough" comes into play. 7 landmarks produced a satisfactory result, without causing excess calculation to be needed.

The variance value of the Gaussian function at each landmark plays a very important role: too small and you move only a small region of pixels, too large and you move portions of the image that are not the mouth. This proved to be crucial and a variance of 15 proved to be perfect.