COL783: Digital Image Analysis

Assignment 2 (Part a): Face Expression Transfer

Deadline: to be declared along with Part (b)

Introduction

In this part of the assignment, we propose to perform face expression transfer from one person to another. Modern-day deep learning algorithms treat this as an image-to-image translation task and propose generative models such as VAEs, GANs, etc. to achieve the same. In this assignment, we take a step back and pose the face expression transfer as a problem of image warping.

Problem statement:

Imagine you have two images I_1 and I_2, one of person P_1 and the other of person P_2, both displaying neutral expressions. Now, consider a third image, I_3, where person P_1 shows an emotion through their facial expression. The challenge is to generate a new image, I_4, where person P_2 exhibits the same emotion and expression as seen in I_3, essentially transferring the facial expression from P_1 to P_2.

Algorithm

We pose facial expression transfer as a problem of image warping. The proposed algorithm is summarized in Figure 1. We find the Warp matrix (H_1) between I_1 and I_2. We now warp images I_1 and I_3 using H_1 to obtain I_1' and I_3' respectively. Thus, the positions of the facial structures of I_1', I_3', and I_2 are now the same. Next, we perform image warping (H_2) between I_1' and I_3'. H_2 gives us the information about the list of changes to be done to the face I_1' to make it look like I_3'. Therefore, we now warp image I_2 using H_2. The resulting image I_4 is the expression transferred image.

Task 1: Warp matrix based expression transfer for one traingle

1. Use your mobile camera and capture at least 5 sets of [I_1, I_2 and I_3]. Make sure all the images in one set have the same background. If possible, set the background to a monochromatic colour. For each of the sets, do the steps 2-6

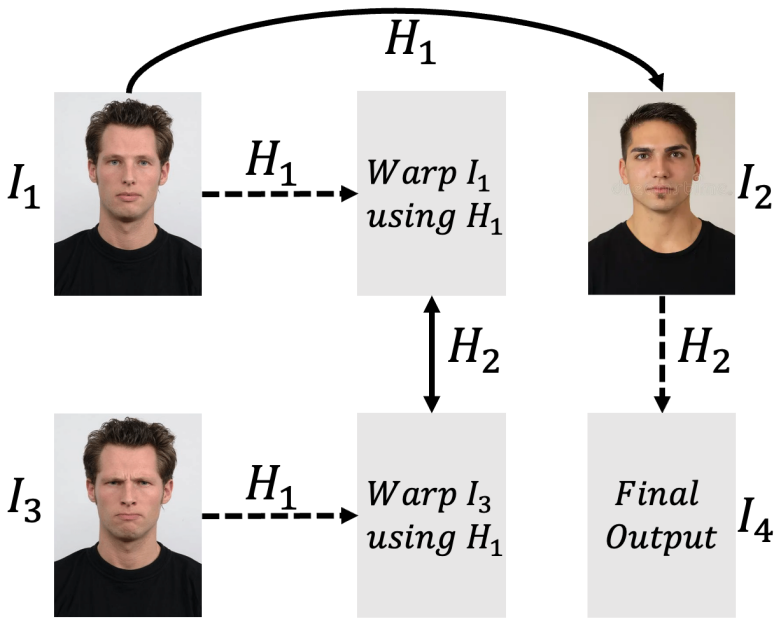

Figure 1: Proposed algorithm for facial expression transfer

2. choose 3 anchor points on each of the images, I_1, I_2 and I_3. These are the points that you will be using to perform image warping. Choose them carefully. Ensure that *point* k of I_1 should semantically correspond to the same point in I_2 and I_3. i.e. if *point* 1 is at the end of the right eye in I_1, it should be at the end of the right eye in I_2 and I_3 also.
3. We observe that these three points on each image form a triangle. Perform triangle-to-triangle mapping.
4. Find the warp matrix (H_1) between the corresponding triangles of I_1 and I_2 and use it to warp I_1. I_1' is obtained after the triangle is warped. Use the same warp matrix H_1 to warp image I_3. You will obtain the image I_3'
5. Now compute the warp matrix (H_2) between the triangles of I_1' and I_3'. Use this information to warp the corresponding triangle of I_2 and obtain I_4
6. Note that in I_4, only one triangle is warped.

Task 2: Barycentric coordinate-based expression transfer for one triangle

1. Use same 5 sets of [I_1, I_2 and I_3] captured in Task 1. Use the same anchor points as chosen there.
2. Use the Barycentric coordinate system and map every pixel inside the triangle of I_1 such that the corners of the triangle chosen in I_1 map to the corners of the triangle chosen in I_2. Thus, we obtain I_1' such that the triangle is warped to the corresponding points in I_2. Similarly, map every pixel inside the triangle of I_3 such that the corners of the triangle chosen in I_3 map to the corners of the triangle chosen in I_2. Thus, we obtain I_3' such that the triangle is warped to the corresponding points in I_2.

3. Now again use the Barycentric coordinate system and map every pixel inside the triangle of I_1' such that the corners of the triangle chosen in I_1' map to the corners of the triangle chosen in I_3' and obtain I_4.
4. Note that, again in I_4, only one triangle is warped. Also, note that in this task of the assignment, we do not find the explicit warp matrix. Instead, we warp it using the barycentric coordinates.

Task 3: Expression transfer over the entire image

1. Use same 5 sets of [I_1, I_2 and I_3] captured in Task 1.
2. choose at least 20 anchor points on [I_1, I_2 and I_3]. These are the points that you will be using to perform image warping. Choose them carefully. Ensure that *point* k of I_1 should semantically correspond to the same point in I_2 and I_3. i.e. if *point* 1 is at the end of the right eye in I_1, it should be at the end of the right eye in I_2 and I_3 also.
3. Perform Delaunay triangulation on each image using the points chosen in the previous step.
4. Now, recursively follow the methodology established in task 1 and task 2 for each of the corresponding triangles to achieve expression transfer. Thus, We will get I_4 such that the entire image has undergone expression transfer. Note that we obtain I_4 using two different mechanisms. Critically compare the two results and provide your insights.

Ensure the images I_1, I_2, and I_3 are of the same dimension. Perform ablations on the number of points chosen for Delaunay triangulation. Report results using the following set of points [1, 5, 10, 20, 30+]. Here, by default, we consider the four corners of the image as four points. Therefore, 1 point essentially means one extra point apart from the chosen 4 points.

Note:-

- The assignment is to be done individually or in a group with a maximum of two members.
- You can use the inbuilt opencv functions to read and write the images. You **CANNOT** use any other inbuilt image processing functions unless explicitly exempted in the description.
- You are required to submit the code, data, and a detailed report for this assignment. The submission can be done using Moodle. Submission instructions will be shared later.
- We shall test the performance of each of your algorithms on a held-out dataset.
- Any sort of plagiarism will lead to serious punishments, depending on the case.