

CSE 568

LAB 3 Report

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Scope -

The aim of this project is to extract individual channels from the given glass photo negatives and then align them using different metrics to form a final colored image. Alignment algorithms expected for frame alignment are SSD (Square of Summed Differences) , NCC (Normalized Cross Correlation) and Harris corner features with RANSAC.

We also concatenate images without any shifts to get an idea of how they look like without frame alignment.

SSD –

We select an ROI of images (Red and Green channel) to be compared over the base image (Blue channel) and slide it over a window of possible displacements like mentioned in the handout (-15: 15). Shifting the images by those pixels and looking for SSD using the formula

$$SSD = \sum (\sum ((image1 - image2)^2))$$

The final ROI window size I settled after multiple tries was a 30x30 window for SSD

We find pixels offsets which satisfy the condition of smallest SSD value and consider them as the offset of the particular image to line-up with blue channel.

NCC –

Was performed similar as SSD the only difference being that we use the formula for NCC and window size chosen was 60x60.

$$NCC = \sum_i \frac{image1_i}{|image1|} \cdot \frac{image2_i}{|image2|}$$

Which could also be written as
$$\frac{\sum(image1 \cdot image2)}{\sqrt{[\sum(image1)^2 \cdot \sum(image2)^2]}}$$

The latter was used in the code.

Instead of looking for lowest value we look for highest correlation value which would correspond to best pixel shift and use those values as an offset to align images.

Harris Corner / RANSAC –

First, we find image gradient (Ix and Iy) and then apply a gaussian filter (using inbuilt imgaussfilt function) to reduce noise on those gradients so we would get distinct corners from the image.

Formula to compute Harris Matrix was used which was:

$$Harris\ Matrix = Det(M) - \alpha * Trace(M)$$

M being a 2x2 Matrix
$$\begin{bmatrix} Ix^2 & IxIy \\ IxIy & Iy^2 \end{bmatrix}$$

Once we get the Harris Matrix, we set a cornerness threshold and look for corresponding maximum value in the said matrix, which would give us the coordinates of the corner features.

Then we choose the top 200 features to perform RANSAC.

Steps executed in RANSAC –

1. Random feature was selected from blue image and Green/Red image.
2. Offset was calculated between those 2 features and the pixel shift was applied to the entire blue image features set; Let's call it B_shifted.
3. Then we iterated through B_shifted and then looked for a corresponding feature in Image2 (Green/Red images), within a threshold, which was a small window created around the feature in Image2.
4. Then we look for how many features lie within the said window and consider them as inliers.
5. Window with highest number of inliers would correspond to the best pixel shift
6. Repeat this process for multiple random features for blue image and Green/Red image. (We keep on increasing the epochs for RANSAC, until multiple runs would give the same output.)
7. These pixel shifts were saved and used as the final pixel offsets for image alignment.

Final Remarks -

Comparing all 3 alignment metrics we notice that the final pixel offsets of similar image with different metrics are identical, with NCC being consistent of all yielding the best results for different images.

Pixel Shifts -

Images below show the individual green and red image pixel offsets to align with blue image for each metric.

```
>> main
Image 1
SSD Red Offsets : 10 , 0
SSD Green Offsets : 6 , 1
NCC Red Offsets : 9 , 0
NCC Green Offsets : 5 , 0
Harris Red Offsets : 10 , 1
Harris Green Offsets : 5 , 2

Image 2
SSD Red Offsets : 10 , 1
SSD Green Offsets : 4 , 2
NCC Red Offsets : 10 , 1
NCC Green Offsets : 4 , 2
Harris Red Offsets : 9 , 3
Harris Green Offsets : 4 , 2

Image 3
SSD Red Offsets : 11 , 2
SSD Green Offsets : 7 , 2
NCC Red Offsets : 15 , 7
NCC Green Offsets : 7 , 3
Harris Red Offsets : -303 , -23
Harris Green Offsets : 14 , -12

Image 4
SSD Red Offsets : 13 , 0
SSD Green Offsets : 4 , 0
NCC Red Offsets : 13 , 1
NCC Green Offsets : 4 , 1
Harris Red Offsets : 13 , 1
Harris Green Offsets : 4 , 1

Image 5
SSD Red Offsets : 11 , 4
SSD Green Offsets : 5 , 2
NCC Red Offsets : 11 , 3
NCC Green Offsets : 5 , 2
Harris Red Offsets : 11 , 5
Harris Green Offsets : 5 , 2

Image 6
SSD Red Offsets : 5 , 1
SSD Green Offsets : 0 , 0
NCC Red Offsets : 5 , 1
NCC Green Offsets : 0 , 0
Harris Red Offsets : 5 , 1
Harris Green Offsets : 0 , 0

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