Report

Assignment 0: Colorizing Prokudin-Gorskii images of the Russian Empire

Detailed instructions

- A brief **description** of your implemented solution, focusing especially on the more "non-trivial" or *interesting* parts of the solution. **What implementation choices did you make, and how did they affect the quality of the result and the speed of computation? What are some artifacts and/or limitations of your implementation, and what are possible reasons for them?**

Anwser:

As we can see from the original images, there is a 'wide' white and black border space around the image, so I use a library/function named `RemoveWhiteSpace` in Mathworks, which helps to remove the borders of the image. Furthermore, I implement another function `crop_center.m` in the code folders is used to remove some of the black borders due to user own choice of percent to remove.

The first trial of implementation is to use the normal way, stacking the three images.

Then I apply the *sum of squared differences (SSD)*, which in MATLAB is simply $sum(sum((image1 - image2).^2))$ method to align the sample images.

The last trial of my implementation is via *normalized cross-correlation (NCC)* method. I use the built-in function `normxcorr2` in MATLAB. Furthermore, duplicate the process in previous stage -- find the best order to align with.

In both of the second and third parts, I take three different orders to align the three images.

For the computation complexity part, SSD has a complexity of $O(n^2)$ and n is the width or the height, depending on the image. Because you need shift the image everytime and compute the SSD score each time. NCC has much lower complexity, much faster than SSD.

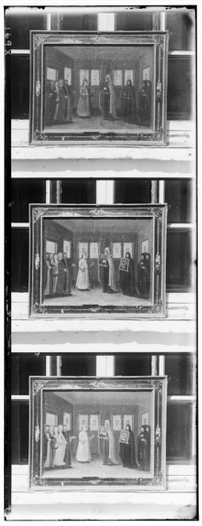
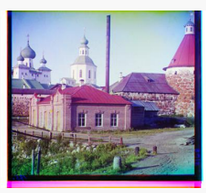
- The output color image for every single input glass plate and the displacement vectors that were used to align the channels. When inserting results images into your report, you should resize/compress them appropriately to keep the file size manageable -- but make sure that the correctness and quality of your output can be clearly and easily judged.You will not receive credit for any results you have obtained, but failed to include directly in the report PDF file.

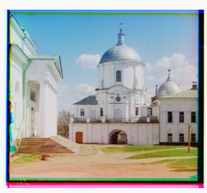
Anwsers

Explanation for SSD with 1, 2 and 3:

SSD-1 uses **blue** channel as reference and shift green and red channel to get the minimal ssd score. Similarlly, SSD-2 uses **green** channel as reference and SSD-3 uses **red** channel as reference.

The results given by SSD are belows:

#	Original	Normal	SSD-1	SSD-2	SSD-3
1					
2					
3					
4					

					
5					
6					

The displacement for each channel is displayed below:

#	Original	SSD -1	SSD-2	SSD-3
1		The displacement for green channel in the first trial is (5, 2). The displacement for red channel in the first trial is (10, 1).	The displacement for green channel in the first trial is (5, 2). The displacement for red channel in the first trial is (10, 1).	The displacement for green channel in the first trial is (5, 2). The displacement for red channel in the first trial is (10, 1).
2		The displacement for green channel in the first trial is (4, 2). The displacement for red channel in the first trial is (9, 2).	The displacement for blue channel in the second trial is (-4, -2). The displacement for red channel in the second trial is (5, 0).	The displacement for blue channel in the second trial is (-4, -2). The displacement for red channel in the second trial is (5, 0).
3		The displacement for green channel in the first trial is (7, 3). The displacement for red channel in the first trial is (-16, 21).	The displacement for blue channel in the second trial is (-7, -3). The displacement for red channel in the second trial is (7, 2).	The displacement for blue channel in the third trial is (7, -18). The displacement for green channel in the third trial is (-7, -2).
4		The displacement for green channel in the first trial is (4, 1). The displacement for red channel in the first trial is (13, 1).	The displacement for green channel in the first trial is (4, 1). The displacement for red channel in the first trial is (13, 1).	The displacement for green channel in the first trial is (4, 1). The displacement for red channel in the first trial is (13, 1).
5		The displacement for green channel in the first trial is (5, 3). The displacement for red channel in the first trial is (11, 4).	The displacement for blue channel in the second trial is (-5, -3). The displacement for red channel in the second trial is (6, 1).	The displacement for blue channel in the second trial is (-5, -3). The displacement for red channel in the second trial is (6, 1).

				
6		The displacement for green channel in the first trial is (0, 0) The displacement for red channel in the first trial is (5, 1)	The displacement for blue channel in the second trial is (0, 0) The displacement for red channel in the second trial is (5, 1)	The displacement for blue channel in the third trial is (-5, -1) The displacement for green channel in the third trial is (-5, -1)

The results given by NCC are belows:

#	image name	NCC-B	NCC-G	NCC-R
1	00125			
2	00149			
3	00153			
4	00351			
5	00398			
6	01112			

The displacement for each channel is displayed below:

#	Image Name	Displacement for NCC-B	Displacement for NCC-G	Displacement for NCC-R
1	00125v	The displacement for green channel is (11, 0). The displacement for red channel is (10, 0).	The displacement for blue channel is (11, 2). The displacement for red channel is (1, 1).	The displacement for green channel is (-4, 2). The displacement for blue channel is (-124, 15).
2	00149v	The displacement for green channel is (5, 1). The displacement for red channel is (8, 1).	The displacement for blue channel is (-3, 1). The displacement for red channel is (6, 1).	The displacement for green channel is (-4, 1). The displacement for blue channel is (-5, 1).
3	00153v	The displacement for green channel is (12, 2). The displacement for red channel is (18, 4).	The displacement for blue channel is (4, 0). The displacement for red channel is (15, 2).	The displacement for green channel is (-7, 0). The displacement for blue channel is (332, 1).
4	00351v	The displacement for green channel is (5, 1). The displacement for red channel is (14, 1).	The displacement for blue channel is (-3, 1). The displacement for red channel is (10, 1).	The displacement for green channel is (-8, 1). The displacement for blue channel is (-13, 1).
5	00398v	The displacement for green channel is (7, 0). The displacement for red channel is (13, 0).	The displacement for blue channel is (-5, 1). The displacement for red channel is (0, 1).	The displacement for green channel is (-5, 1). The displacement for blue channel is (-154, -10).
6	01112v	The displacement for green channel is (1, 2). The displacement for red channel is (-67, 3).	The displacement for blue channel is (1, 0). The displacement for red channel is (-66, 2).	The displacement for green channel is (-7, 0). The displacement for blue channel is (-171, -9).

Bonus Points

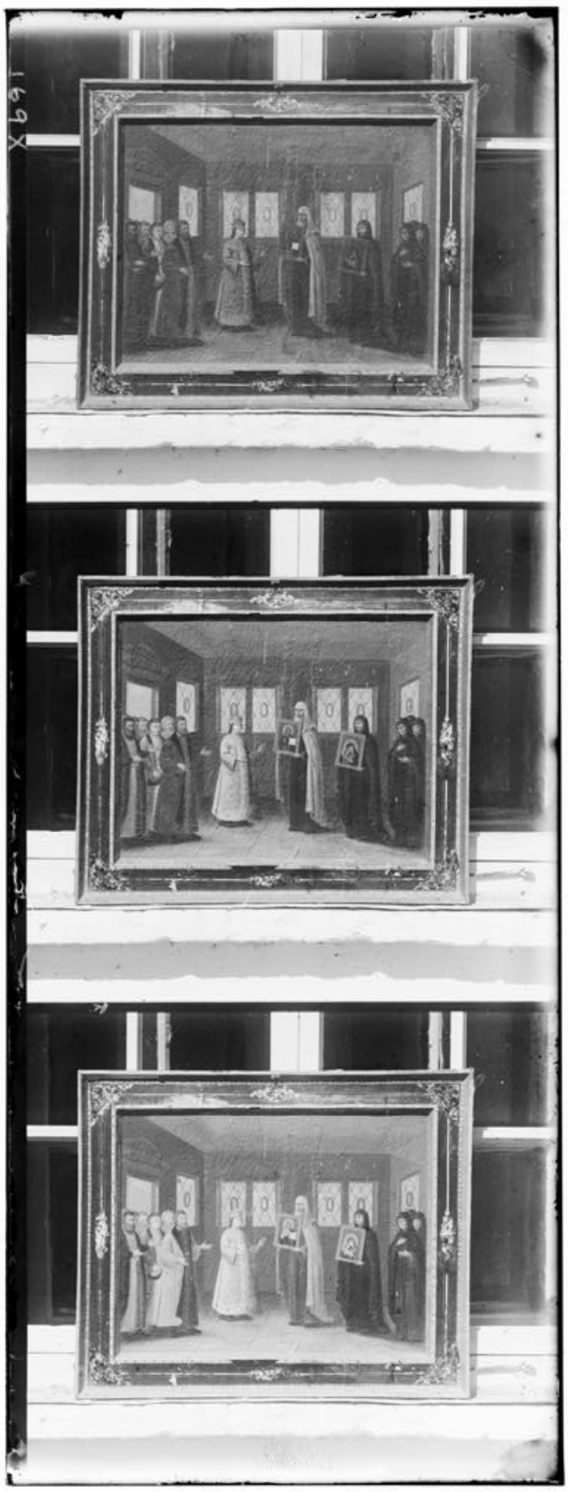
- Any bonus improvements you attempted, with output. If you implemented a multiscale solution, report on its improvement in terms of running time (feel free to use an estimate if the single-scale solution takes too long to run). Any parts of the report you are submitting for extra credit should be clearly marked.

I implemented a `crop` function which is used to crop the borders. Also Iused `RemoveWhiteSpace` function to remove the white space aroud the image. The ratio of `crop` function is decided by users. For this program, I selected 0.08 for the 'ratio'. Besides, the `RemoveWhiteSpace` function written by `Reza Farrahi Moghaddam`, the webpage can be found here. Below is the table that removes the white space around all of the original images.

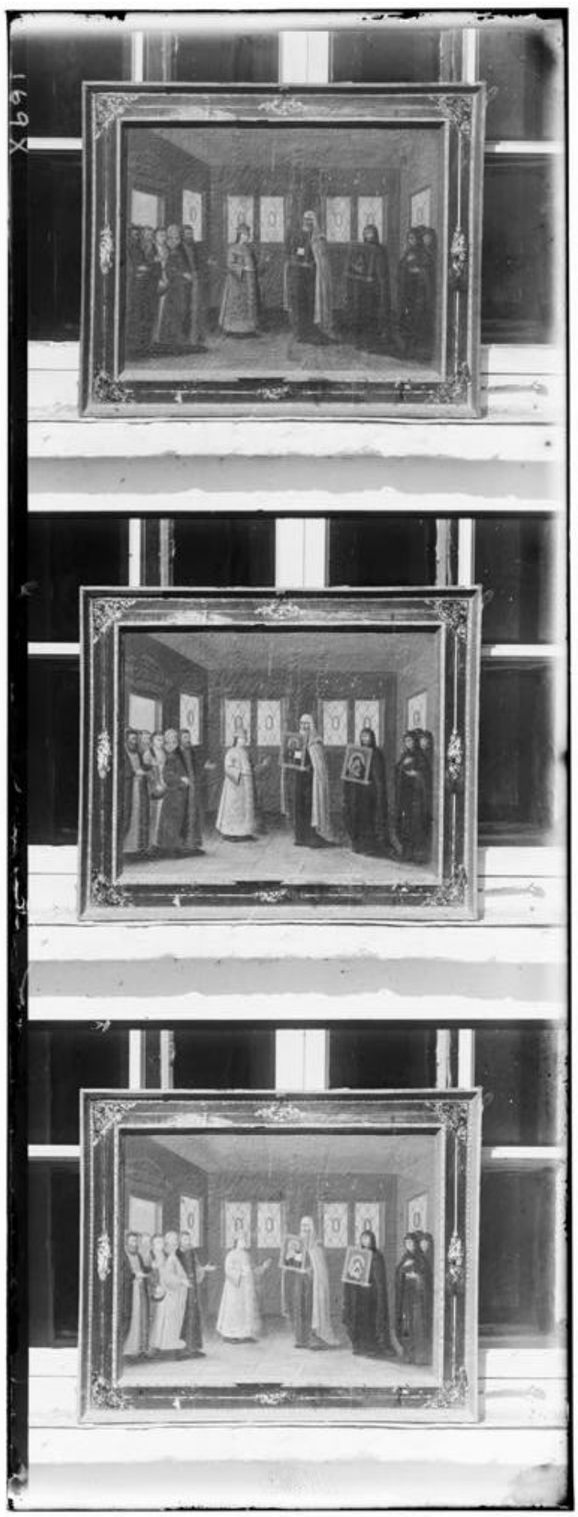
#	Original	RemoveWhiteSpace

1		
	The size of original image is (1024, 400).	The size of cropped image is (1007, 384).

2



The size of original image is (1024, 397).



The size of cropped image is (1013, 392).

3	 The size of original image is (1024, 394).	 The size of cropped image is (1016, 382).

4	 The size of original image is (1024, 396).	 The size of cropped image is (1008, 384).

5		
	The size of original image is (1024, 397).	The size of cropped image is (1016, 393).

6		
	The size of original image is (1024, 393).	The size of cropped image is (1024, 393).