Samuel George
Comp 775, Assignment 3

Assignment Three

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I have neither given, nor received, unauthorized aid on this assignment. Worked with Christopher Bender, Jack Shi, and Ahsan Mahmood in developing the algorithms and understanding to do the assignment. No code was directly shared.

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Part 1:

Below are the different Metrics for each of the types of measures we used for registration. The first is Normalized Cross Correlation:

		Norm Cross Correlation	
	Angle Found (Accuracy)	Local Min vs Global Min Difference	Sharpness of Second Derivative (3 point fit polynomial)
Target (A=1, B=0)	0.0625	0.0026033	591.23
Target (A=1000, B=0)	0.0625	0.0026033	591.23
Target (A=1000, B=1000)	0.0625	0.0026033	591.23
Target (A=-500, B=1000)	-0.0625	0.81872	590.82

Below are the metrics for Mutual information as a measure for registration:

		Mutual Information	
	Angle Found (Accuracy)	Local Min vs Global Min Difference	Sharpness of Second Derivative (3 point fit polynomial)
Target (A=1, B=0)	0.0625	0.25129	9.63E+05
Target (A=1000, B=0)	0.0625	0.25129	9.63E+05
Target (A=1000, B=1000)	0.0625	0.25129	9.63E+05
Target (A=-500, B=1000)	0.0625	0.25129	9.63E+05

Finally, we have the metrics for my own quantile function. Details on how the quantile function was made are given later:

		My Quantile Function	
	Angle Found (Accuracy)	Local Min vs Global Min Difference	Sharpness of Second Derivative (3 point fit polynomial)
Target (A=1, B=0)	0.0625	0.22208	39301
Target (A=1000, B=0)	0.0625	0.22208	39301
Target (A=1000, B=1000)	0.0625	0.22208	39301
Target (A=-500, B=1000)	0.0625	0.22208	39301

In terms of performance both Mutual Information (MI) and my Quantile Function (QF) far outperformed the normalized cross correlation (NXC) method. Both MI and QF were resistant to A being negative and were able to find the correct angle, even when the colors were inverted. Both MI and QF also showed much higher local v global min difference and higher sharpness of the second derivative than NXC. In terms of MI vs QF, both had very comparable levels of difference in local v global difference. They also showed comparable second derivative sharpness. Overall, I'd say MI was the best, but QF would be a very close second and in different circumstances may perform better. Note you could also tune the number of quantiles in my QF to get varying degrees of performance. Also, a 3 point fit polynomial was chosen for sharpness because it yielded the most accurate fit for both QF and MI. NXC was made 3 to match so there would not be any bias in fit.

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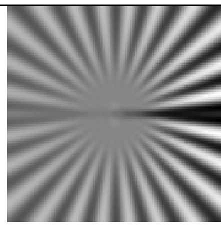
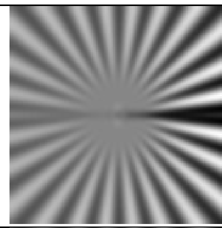
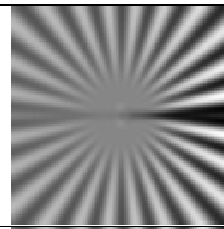
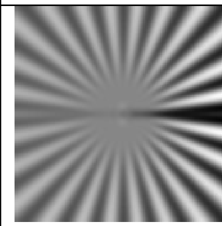
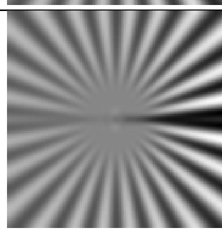
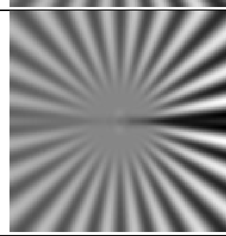
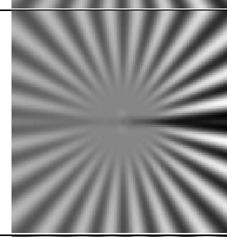
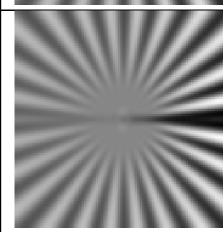
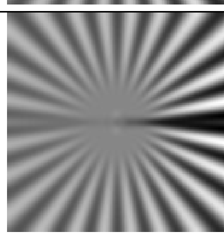
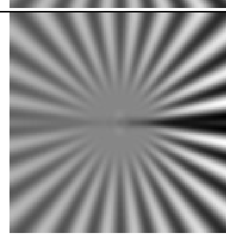
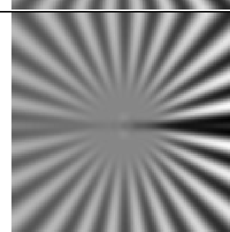
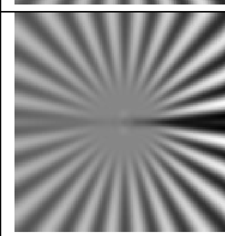
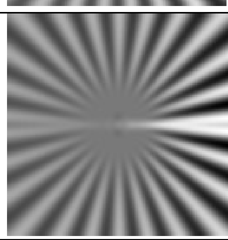
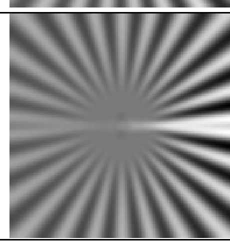
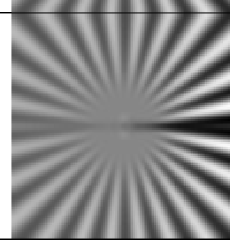
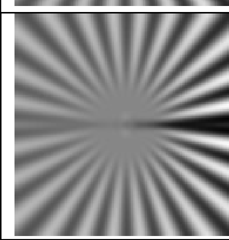
Part 2: Below is a table showing the target image and resulting reference images after registration using each of the measures discussed above:

	Target	Normalized Cross Correlation	Mutual Information	My Quantile Function
Target (A=1, B=0)				
Target (A=1000, B=0)				
Target (A=1000, B=1000)				
Target (A=-500, B=1000)				

Note that for the target images above, I used the mat2gray function in MATLAB before printing the target image. Therefore, all conditions except the A=-500 image look very similar. However, I did not do that scaling prior to running NXC, MI, or QF on the target image and reference image.

Part 3:

My Quantile Function (QF) was built in the following way. First, both the reference and target images are scaled between 0 and 1 using the mat2gray function in MATLAB. Next, the gradient of the images was calculated for angle 0 to pi/2 (top right quadrant) in the images, and the magnitude of that gradient was calculated as well. Collecting the magnitudes of the gradients in an array for both the reference and target images results in an array of magnitudes for the selected region for both images. The array for each image (target and reference) was then sorted and broken into 40 pieces based on the sum of each section of sorted data to create our piecewise representation of our quantile function. The

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Euclidian distance between these two quantile functions was then calculated. This served as a metric for image match where 0 is a perfect match and anything higher is a mismatch. The distances across all angles were collected and scaled between 0 and 1 and subtracted from 1 so that 1 means the closest match and 0 is the least amount of match. This function of theta vs measure can be used to assess which angle of rotation yields the highest correct match and we can calculate all the necessary metrics from this theta vs measure set. Because we are doing the magnitude of the derivative as the base metric, it is immune to white on black or black on white changes and instead matches based on image change. The reason for scaling both images prior to this analysis is so that gradients of the images are comparable and immune to scale. Overall, this yields a very nice registration.

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Appendix:

All code located at the address below:

https://github.com/SamuelDGeorge/Comp_775_Assignment_3

Mutual Information Function found here:

https://www.mathworks.com/matlabcentral/fileexchange/13289-fast-mutual-information-of-two-images-or-signals