Computational Photography

Assignment #5: HDR

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CS6475 - Fall 2019

Result from Example Input

Demonstrate your HDR output from your basic code, using the provided images in the input folder.

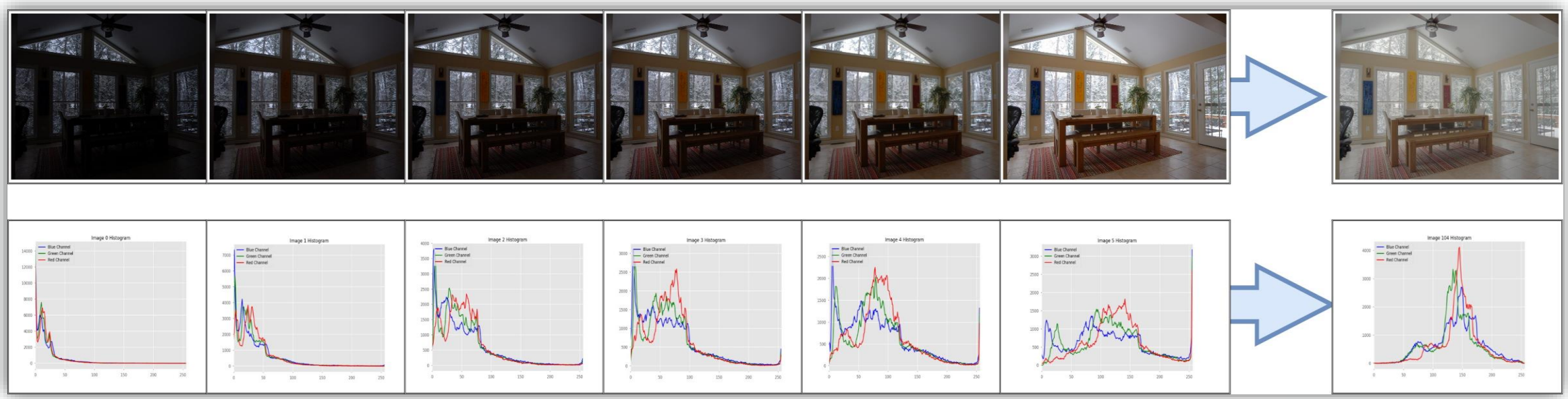
- Did you get a good result? If yes/no, what specifically were you happy/unhappy with? Be detailed in your answer.

This is the result from the basic developed code. The result is acceptable but is far from great. The image looks washed out and lacks details in certain areas. Since this is the basic code result, I do not expect much when it comes to color accuracy or detail preservation.

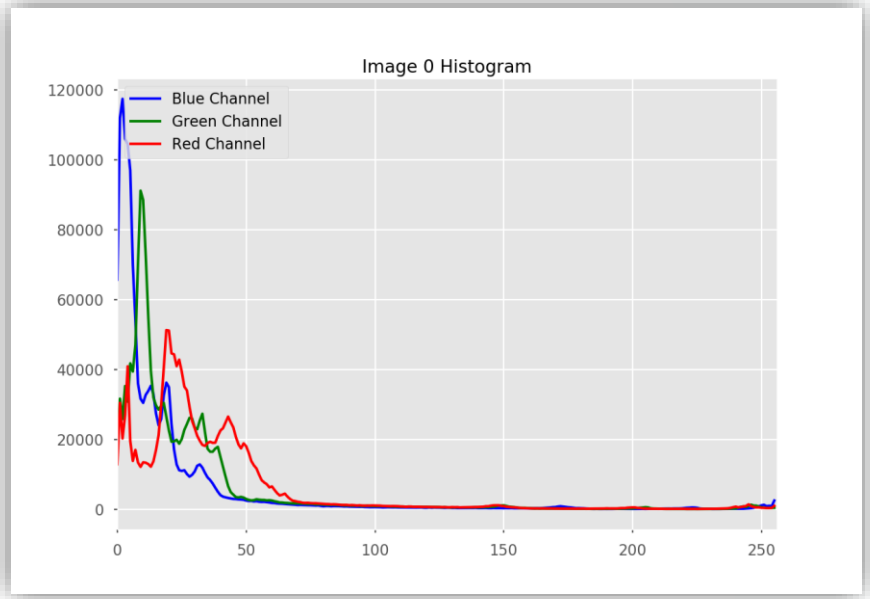
Result from Example Input

Demonstrate your HDR output from your basic code, using the provided images in the input folder.

- This is a combination of the test images we are supplied. I generated histograms for the 3 different color channels in each image. I found this interesting because as we increase the levels of exposure; we observe an increase in higher intensity pixels. While it is logical this would be the result, seeing the histograms with its respective images; helps to solidify how the exposure impacts the image.



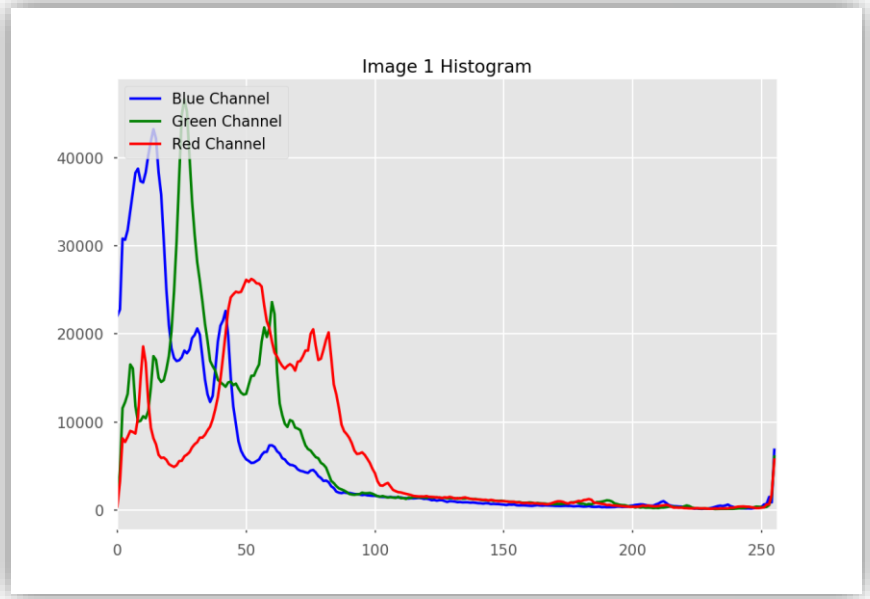
HDR Image Components Thumbnails



- **Exposure Time: 1/160sec**
- **Aperture: 3.6171875**
- **ISO: ISO-400**

(No Source Needed, I took the pictures)

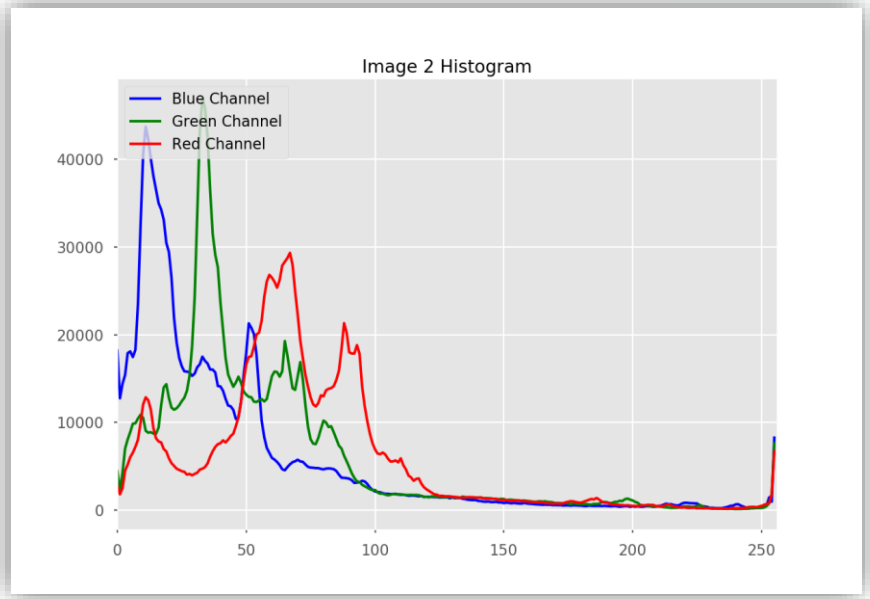
HDR Image Components Thumbnails



- **Exposure Time: 1/125 sec**
- **Aperture: 3.6171875**
- **ISO: ISO-400**

(No Source Needed, I took the pictures)

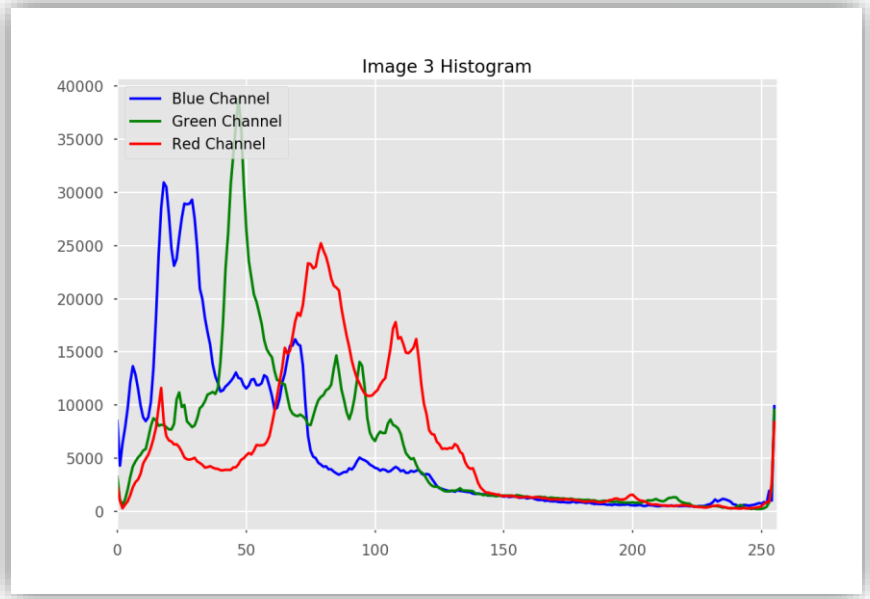
HDR Image Components Thumbnails



- **Exposure Time: 1/80sec**
- **Aperture: 3.6171875**
- **ISO: ISO-400**

(No Source Needed, I took the pictures)

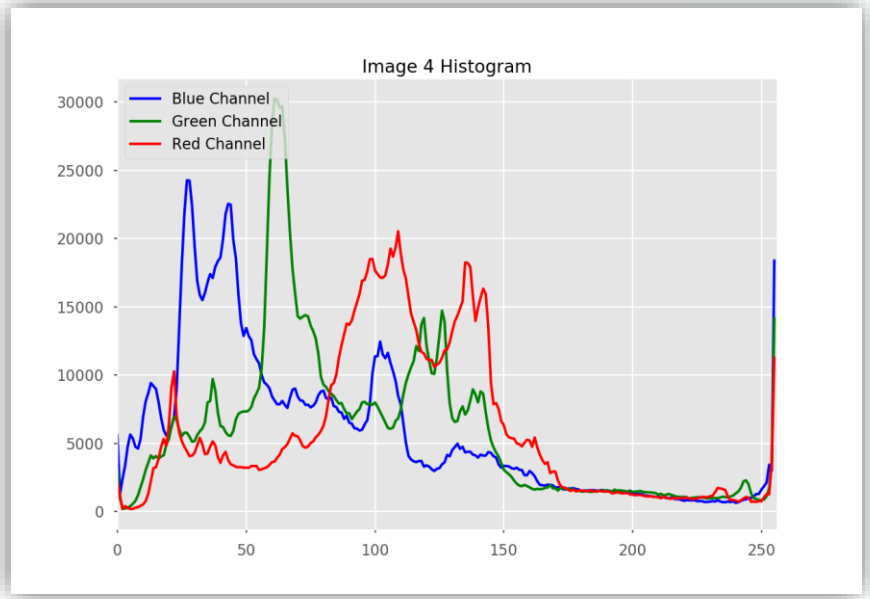
HDR Image Components Thumbnails



- **Exposure Time: 1/60sec**
- **Aperture: 3.6171875**
- **ISO: ISO-400**

(No Source Needed, I took the pictures)

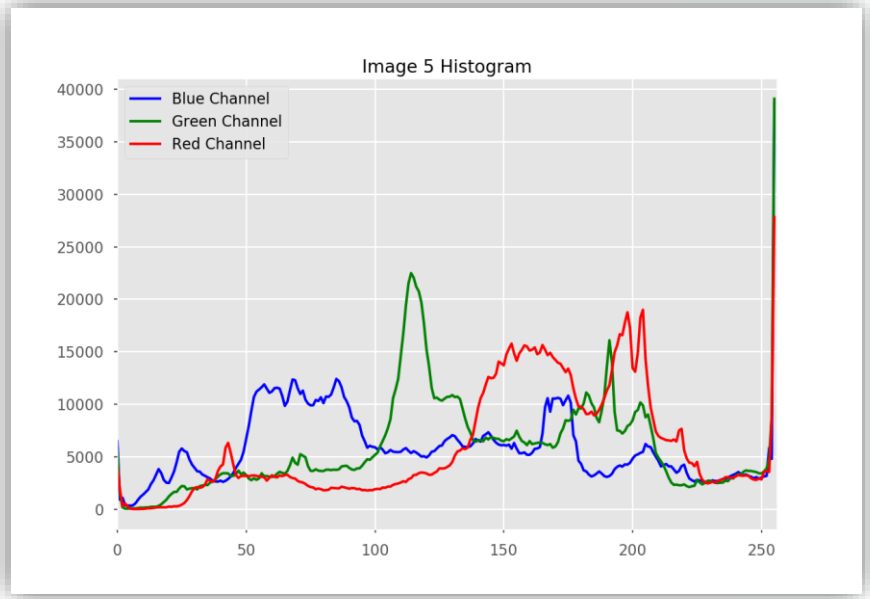
HDR Image Components Thumbnails



- **Exposure Time: 1/40sec**
- **Aperture: 3.6171875**
- **ISO: ISO-400**

(No Source Needed, I took the pictures)

HDR Image Components Thumbnails

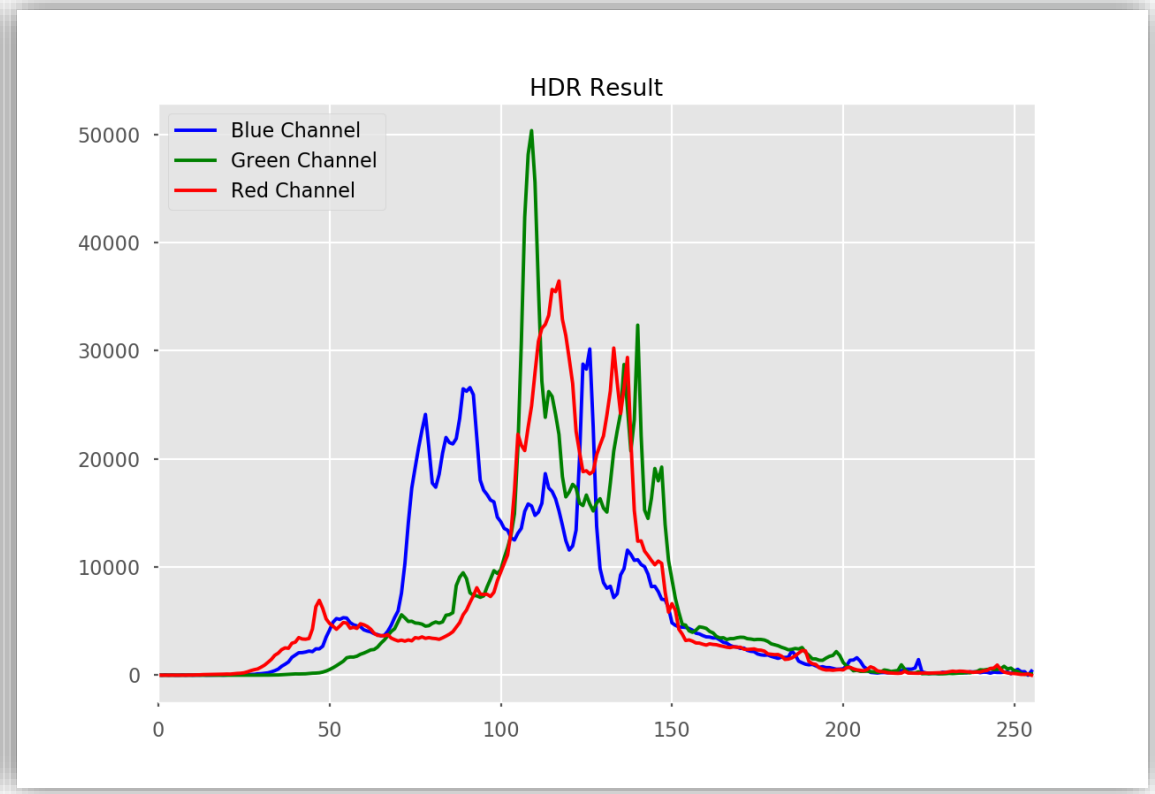


- **Exposure Time: 1/15sec**
- **Aperture: 3.6171875**
- **ISO: ISO-400**

(No Source Needed, I took the pictures)

Final HDR Image

Demonstrate your HDR output from your basic code, using your HDR images (either from the web or your own).



HDR Image Requirements

- Discuss the camera setting requirements for an HDR image set in general. What settings should be the same for all images? Why?

In general you want to keep all settings stagnant, except for the exposure. You take multiple images above and below the expected exposure. This allows you to take an average of the exposures or to model the curve of the various color channels of the images and essentially take the ‘best’ features of all images. Lower exposure images may show details that an image with higher exposure does not. This is the point of HDR to capture more information by changing how sensitive the cameras sensor is to light.

- What is the relevance of the number series (-2, -1, 0, 1, 2) for the exposure times for an HDR image set? Did your images follow this exposure relationship? Explain using your image exposure times.

Yes, my images did follow this exposure relationship as I used the same exposures that the sample images used. Essentially you are wanting to take pictures with lower and higher exposures. 0 should represent the estimated ‘best’ exposure. You take pictures with higher and lower exposure than the ‘best’ and then process those to produce the HDR image. For my images, my exposure time of 1/15 would be my 2, 1/40 would be 1. My best exposure is somewhere in between 1/80 and 1/60 those would represent the 0. The 1/125, 1/160 are the -1 and -2 respectively.

HDR Image Requirements cont.

- What else besides camera settings must be controlled for an HDR image set?

When attempting to make an HDR image set there are multiple things to consider and try to control. You want to make sure the camera is in the same spot for each image. If you are not able to, you may need to process the images further as we did in the Panorama and try to find matching areas of the images so you can then align them correctly. I had to align my images because I was not able to keep my camera completely still throughout the image set.

Discussion of Results

- How well does your HDR output represent the input image set? Discuss!

Using the basic HDR code produced results which were sub-par but acceptable. The image was washed out and the HDR code introduced some artifacts into the image. I found that with higher resolution source images, those artifacts were significantly reduced but dramatically increased processing time.

- What worked well? Be specific.

What worked well was the MatLab code provided in the research paper. Only minimal changes were needed to implement the code in python. I implemented a fast version of this code which processed the HDR image much faster than the loops used in the basic version. I did have to change functionality of some methods to accept arrays vs single values.

- What did not work well? Be specific. Were there any problems you couldn't solve? What were they? If you had more time, how would you solve these problems?

One aspect of this project which could have been improved, would have been some of the instructions in the supplied starter code. In some instances the instructions were confusing. I was not able to apply an accurate tone map to my final image. If I had more time, I would have tried to implement a better way of obtaining and applying a generated tone map to my results.

Discussion of Results cont.

- Reflect on the project: Knowing what you do now (at the end), if you were to start over, what would you do differently and how would you go about doing it?

If I were to start over, I would put more effort into keeping my camera from moving. I tried using our feature detection from our panorama assignment, but the effort was not worth the result. I then switched to OpenCV's createAlignMTB to align my images and this was easier to implement. While I did have images that had move too far for this function to be successful, for the majority, it was able to align my images very well.

Above & Beyond : Tone Mapping

- For the Above & Beyond section I will be using photographs I took and process them using multi different tone mapping variations. I will put in the parameters which I varied through out the testing. I used gamma 0.1-1.0 in 0.1 increments and the same for saturation.

  e.g. Cv2.createTonemapDrago(gamma, saturation) means I worked with the Drago tone mapper and changed the gamma and saturations for that variation.

- Cv2.createToneMap(gamma)
- Cv2.createTonemapDrago(gamma, saturation)
- Cv2.createTonemapMantiuk(gamma, saturation)
- Cv2.createTonemapReinhard(gamma, color_adapt)
- Cv2.createTonemapDurand(gamma, saturation)
- ‘Intro to Python Image Processing in Computational Photography’ by Radu Balaban (n.d.)

Cv2.createToneMap(gamma)

- I am using the standard method from OpenCV with many different gamma levels.
- The best results that I obtained were using createToneMap with a gamma of 0.7
- When looking at the images for the HDR result and the HDR result with matched histograms, you are not able to see much of a difference. When the images are larger you can see much more clearly the histogram matched image has cleaner lines better colors. Specifically if you look at the building that is in the window and the ‘EXIT’ sign you can see the differences much easier.

HDR Result

HDR Matched Histogram

Top_Left is basic code HDR result. Bottom_Left is the result where I matched the histogram of the basic HDR result to the middle image in the image stack. The right-side images are the results with different settings using the specified tone map.

Cv2.createTonemapDrago(gamma, saturation)

- I use the Drago tone map in this situation and again with many different variations of Gamma and Saturation.
- Drago was one of the best tone maps I used. I found that a Gamma of 0.8 and a Saturation of 0.7 produced nice results.
- I found that the colors were brought back from the somewhat washed out colors of the different HDR results.

HDR Result

HDR Matched Histogram

Top_Left is basic code HDR result. Bottom_Left is the result where I matched the histogram of the basic HDR result to the middle image in the image stack. The right-side images are the results with different settings using the specified tone map.

Cv2.createTonemapMantiuk(gamma, saturation)

- I am not sure if I used the Mantiuk tone mapping method correctly, but the results were no better than using the default CV2.CreateToneMap
- I do think the colors of the histogram matched image, were more pronounced than the basic HDR image.

HDR Result

HDR Matched Histogram

Top_Left is basic code HDR result. Bottom_Left is the result where I matched the histogram of the basic HDR result to the middle image in the image stack. The right-side images are the results with different settings using the specified tone map.

Cv2.createTonemapReinhard(gamma, color_adapt)

- I do think the results of the Reinhard tone mapping method was adequate, if you look at the windows at the top of the image, you see artifacts in the image.
- I still prefer Balaban's tone mapping method, as it allows for the most configuration.

HDR Result

HDR Matched Histogram

Top_Left is basic code HDR result. Bottom_Left is the result where I matched the histogram of the basic HDR result to the middle image in the image stack. The right-side images are the results with different settings using the specified tone map.

Cv2.createTonemapDurand(gamma, saturation)

- I believe Durand is the tone map to use if you want to make minor adjustments for perfection.
- I personally was not able to devote enough time to just this tone map to produce much better results.
- I did find while trying to produce better results by varying the gamma and saturation high, would introduce more artifacts into the image. If you look at the very bright windows in the top-middle of the image, that is where the artifacts begin developing.

HDR Result

HDR Matched Histogram

Top_Left is basic code HDR result. Bottom_Left is the result where I matched the histogram of the basic HDR result to the middle image in the image stack. The right-side images are the results with different settings using the specified tone map.

‘Intro to Python Image Processing in Computational Photography’ by Radu Balaban (n.d.)

- These are my results from using Balaban’s method for tone mapping.
- I believe that Balaban’s method produced the best results out of the various tone mapping methods I used.
- The colors were brought back much more naturally than the previous methods.
- The indoor area of the image was clear and so is the outdoor area.

HDR Result

HDR Matched Histogram

Top_Left is basic code HDR result. Bottom_Left is the result where I matched the histogram of the basic HDR result to the middle image in the image stack. The right-side images are the results with different settings using the specified tone map.

Discussion of Results cont.

If you have any HDR image sets that failed, include them in this 'Discussion of Results' section and explain why each set failed. You may use additional slides if necessary

- Side Observation

When doing the histogram matchings I found that it removed some artifacts that were introduced during the HDR process. The problem was caused when my camera was slightly moved during the various captures. The top two images show how the camera moved. The bottom left is the HDR result based strictly on those input images. The bottom right is a histogram matched version of the HDR result. I found this to be interesting as the artifact was removed as well as the buttons that are visible in the bottom left image.

Discussion of Results cont.

If you have any HDR image sets that failed, include them in this 'Discussion of Results' section and explain why each set failed. You may use additional slides if necessary

- Failed Results

I did have failed results by I believe the issues was that I was using my iPhone 11 to take the images and using the app ProCam to try and manually adjust the exposure for the images. As well as I had failures with image alignment. This failure I found to be the most interesting, it was caused by having my source images in the wrong order. While the intended outcome was incorrect, the result almost looks intentional.

Resources

Record your sources here. We accept all reasonable formats that would allow us to verify your sources.

- Piazza posts
- Recovering High Dynamic Range Radiance Maps from Photographs by Paul Debevec and Jitendra Malik
- https://towardsdatascience.com/hdr-imaging-what-is-an-hdr-image-anyway-bdf05985492c
- https://medium.com/@rndayala/image-histograms-in-opencv-40ee5969a3b7 – Histogram Generation (was not included because I needed to import MatPlotLib to plot them and we are not allowed to import things)
- https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_histograms/py_histogram_begins/py_histogram_begins.html – Histogram Generation (was not included because I needed to import MatPlotLib to plot them and we are not allowed to import things)
- Balaban, R. (n.d.) Intro to Python Image Processing in Computational Photograph. Retrieved from https://www.toptal.com/opencv/python-image-processing-in-computational-photography

Resources

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- https://medium.com/@andykashyap/top-5-tricks-to-make-plots-look-better-9f6e687c1e08
- Draw.io – For some of the graphs/charts
- Pyimagesearch.com Tutorial on Histogrammatching–Histogram Matching
- https://vzaguskin.github.io/histmatching1/Histogram matching in python by Victor Zaguskin
- https://www.slideshare.net/yuhuang/image-color-correction-contrast-adjustment
- https://www.learnopencv.com/high-dynamic-range-hdr-imaging-using-opencv-cpp-python/ - Aligning images since I did not have a tri-pod

Remember: It is plagiarism if you don't reference your sources!

Resources

Record your sources here. We accept all reasonable formats that would allow us to verify your sources.

- Raw Images Folder on Dropbox - https://www.dropbox.com/sh/pl7ak1xcesmbdpi/AACPhXbgLsXO6lf7-V22SSq3a?dl=0
- This folder should allow access to all images, if not there are separate links below
- Image_1 - https://www.dropbox.com/s/4psse896ixl4alj/input_1.JPG?dl=0
- Image_2 - https://www.dropbox.com/s/ed5hpzhw3tflv6z/input_2.JPG?dl=0
- Image_3 - https://www.dropbox.com/s/ozdednzyh8dpt3q/input_3.JPG?dl=0
- Image_4 - https://www.dropbox.com/s/j8zg474oehmprcp/input_4.JPG?dl=0
- Image_5 - https://www.dropbox.com/s/fetbk5u1o8i3qh5/input_5.JPG?dl=0
- Image_6 - https://www.dropbox.com/s/sfzrgh4qy4yon7d/input_6.JPG?dl=0