BIL 415 - Image Processing Practicum

Due Date: 23:00 pm on Friday, December 14th, 2018

Enhancing Dark Images

(a) no-flash   (b) flash   (c) basic reconstruction   (d) shadow treatment

Figure 1: Example results.

In this assignment, you are going to implement a basic version of a previous study [1], by utilizing the Bilateral Filter. You will use given image pairs such that one with the available light and one taken with the flash.

While taking a photograph at a dark place in the absence of the flash, we usually can not get the color information accurately and the image gets noise. On the other hand, we can get more reliable color information and sharpness if we use flash but we lose the original lighting/ambiance in the image. By following the basic steps of the proposed method, you will preserve the ambiance of the original lighting from no-flash image and insert the sharpness and more reliable color information from the flash image. In other words, you will combine the illumination component of the no-flash picture and the structure component of the flash picture. While doing this, you will utilize the Bilateral Filter to smooth the noise from no-flash image's intensity layer and get the accurate edge information from the flash image.

At the end, you will obtain an enhanced version of the dark image (see Figure 1 (c)) . Instead of using the one taken with the flash directly, you will get the original image's warm atmosphere as well, since flash generally causes flat and harsh lighting. The steps are explained below but for more details, please read the Section 2 in the referenced study [1].

PART 1: Bilateral Decoupling and Reconstruction

First of all, you will decouple the images into intensity and color layers as shown at Figure 2 in [1]. You will get the intensity layer basically using the grayscale image of both no-flash and flash images. After that, in order to obtain the color layer, you will divide original pixel values of each channel with the intensity layer. **Do not forget to convert images to float before doing any division/multiplication.** You will not use the color layer of no-flash image, instead, you will use the color information from flash image. Explain the reasons and the background information why the color layer of no-flash image is not useful and why we are using the color layer of flash image.

After that, you will apply Bilateral Filter to the intensity layers by using OpenCV's built-in function. You will get the large-scale layer by filtering the intensity layer of no-flash image. Why are we doing smoothing on no-flash image's intensity layer and what is the advantage of Bilateral Filter? Please explain.

Now you will apply the Bilateral Filter to flash image's intensity layer to get its large-scale layer. Then, you will get the edge/sharpness details by dividing the flash images's intensity layer to its large-scale layer. Why are we using the large-scale layer of the no-flash image instead of the flash image? Please explain.

Since you have the details from flash image, large-scale layer from no-flash image and the color layer from flash image, now you will combine them. Basically, you will multiply the large-scale layer and detail layer to obtain intensity values that include the sharp edge information as well. After that, you will multiply this intensity with each channel of color layer to get the reconstructed and enhanced image.

Give your resulting images for each step similar to Figure 2 in [1]. Do not forget to normalize your values and convert them to "uint8" for visualization of intermediate steps.

PART 2: Experiments

You should observe the effects of three parameters in the Bilateral Filtering which are the two sigma values and the kernel size by experimenting with different values. Explain how this filter works base on its formula and the resulting images by answering these questions: How does it implement smoothing? How does it preserve edges? *(Note: You will get more points for Bilateral Filtering examination.)*

You should experiment with different intensity layers such as the one from Lab/HSV color spaces or the one that is explained in the Appendix of [1]. How is the result affected? Give your comments on why the quality of the intensity layer is important for this problem, which is also explained in [1].

Lastly, experiment with **two additional image pairs** from [2] and give your comments on the results such as what are the differences between the results, examine the images based on their intensities.

PART 3: Shadow Treatment (Bonus)

Since you will implement the first basic steps of this work [1], you will see some artifacts which come from the flash image due to the shadows (see Figure 1 (c)). Examine the methods that they propose to remove the shadows (see Figure 1 (d)) in Section 3 of [1]. Try to implement some steps in order to get rid of the shadow effect. You are encouraged to come up with your own ideas and implementation as well.

The Implementation Details

1. There is no restriction for built-in functions.

2. You are expected to write functions for each operation and give a main script to run all results. You can create classes for different parts that include the functions and you can import your classes to your main script.

3. You should pay attention to code readability such as comments, function/variable names and your code quality: 1) no hard-coding 2) no repeated code 3) cleanly separate and organize your code 4) use consistent style, indentation 5) write deterministic algorithms

4. Implement your code with Python 3 and use libraries from Anaconda. You can install any library that is not in Anaconda as well, such as OpenCV 3.

What should you write in the report?

- Give your resulting images step by step for each part.

- Give experimental results, used parameters and comments on the results in detail.

- Explain your implementation and code as well as your approach to the problem.

- A basic structure might be: 1) Introduction (what is the problem, how do you approach to this problem, what is the content of your report) 2) Implementation Details (the method you followed, the organization of your code, functions and details of your solution) 3) Experimental Results (all results for separate parts with different parameters and your comments on the results) 4) Conclusion (what are the results and what are the weaknesses of your implementation, in which parts you have failed and why, possible future solutions)

- You should write your report in LaTeX

Grading

The assignment will be graded out of 100:

- **40 (part 1):** CODE: 0 (no implementation), 15 (a partially correct solution), 25 (a correct solution) and REPORT: 15

- **60 (part 2):** CODE: 0 (no implementation), 15 (a partially correct solution), 25 (a correct solution) and REPORT: 35

- **25 (bonus):** CODE: 0 (no implementation), 10 (a partially correct solution), 20 (a correct solution) and REPORT: 5

Late Policy

You have three days for late submission. You will lose 10 points from maximum evaluation score for each day (your submitted study will be evaluated over 90, 80 and 70 for each late submission day). You have to submit your solution in deadline date + three days, otherwise it will not be evaluated.

Academic Integrity

All work on assignments must be done individually unless stated otherwise. You are encouraged to discuss with your classmates about the given assignments, but these discussions should be carried out in an abstract way. That is, discussions related to a particular solution to a specific problem (either in actual code or in the pseudocode) will not be tolerated. In short, turning in someone else's work, in whole or in part, as your own will be considered as a violation of academic integrity. Please note that the former condition also holds for the material found on the web as everything on the web has been written by someone else.

References

[1] Eisemann, Elmar, and Frédo Durand. "Flash photography enhancement via intrinsic relighting." ACM transactions on graphics (TOG). Vol. 23. No. 3. ACM, 2004.
[2] http://maverick.inria.fr/Publications/2004/ED04/