2015

Color2Gray Algorithm Implementation Project

CS510 – COMPUTATIONAL PHOTOGRAPHY

NAN HU

Abstract

In my CS510 Computational Photography project, I have the topic that turning color image to grayscale image with loosing as least details as it can. The algorithm that I choose is from one of the paper that instructor given which is "Apparent Greyscale: A Simple and Fast Conversion to Perceptually Accurate Images and Video" written by Kaleigh Smith and his team. By applying this algorithm, I am going to implement this algorithm in C++ using OpenCV. My expectation would be self-implement the algorithm that discussed in paper, and try to make it work in small or medium size picture. In my point of view the algorithm that I implement should create a perceptually accurate version of the color image that represents its psychophysical effect on a viewer. I will try to implement algorithm that works on small image.

Introduction

In the paper that I implemented, it shows the current situation and basic problem for turning color image to grayscale image. The basic problem of grayscale transformation is to reproduce the intent of the color original, its contrasts and salient features, while preserving the perceived magnitude and direction of tis gradients. My implementation of this paper's algorithm includes two independent tasks. First, I write a mapping that assigns a grey value to each pixel or color. Second, I generate discriminability constraint so that the chromatic differences match their corresponding original color differences. The paper also discuss about the disadvantages for this algorithm. The greyscale images may exhibit exaggerated dynamic range, and arbitrary chromatic order that differs among color palettes, and a smoothing or masking of details. The goal of this implementation is trying to implement this algorithm and getting as similar as the result that paper provided for a medium or large image to see the runtime performance.

Global Apparent Lightness Mapping

In my Implementation, I first convert the color image to linear RGB by inverse gamma mapping, then transform to CIELUV color space. Third I convert the L channel into Nayatani model which shows the equation below:

$$L^*_{N_{VAC}} = L^* + [-0.1340\, q(\theta) + 0.0872\, K_{Br}]\, s_{uv}\, L^*$$

Fourth, I map L_N to grey scale Y values using reference white chromatic values for u and v channel. Last, I apply gamma mapping to move from linear Y space back to gamma-corrected greyscale image G. The pipeline shows below is the entire process how mapping work:

$$I_{RGB} \rightarrow I_{LUV} \rightarrow I_{L^*_N} \rightarrow G$$

Local Chromatic Contrast Adjustment

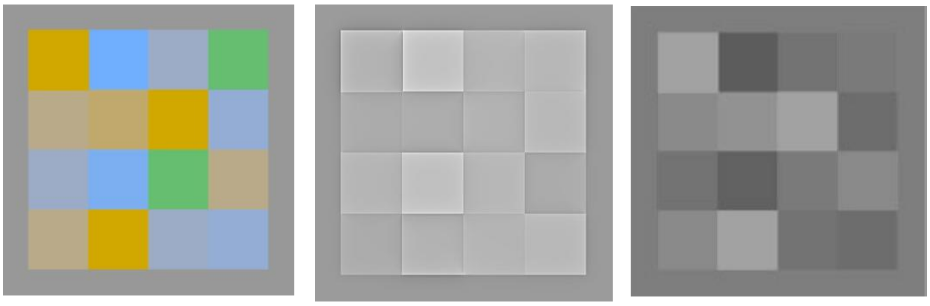
In the paper, they mentioned that increasing local contrast in the greyscale image G to better represent the local contrast of original I to counter information loss. Here is the step by step that I implement the local contrast adjustment. First, I decompose the image into several band-pass. Second, image local contrast will be increased by amount of lambda for each scale in Laplacian Pyramid. Lambda is the goal of gain factor to measure the remaining chromatic contrast to be restored during enhancement. The lambda is to measure the remaining chromatic contrast to be restored during the enhancement.

$$\lambda_i = \left(\frac{\Delta E(h_i(I))}{|h_i(G_{L^*})|}\right)^p$$

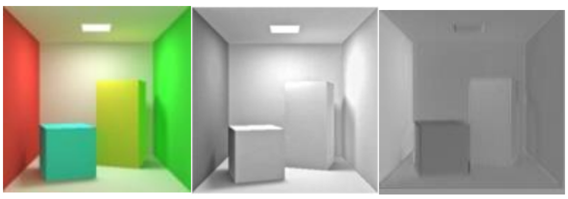
Finally, the implementation will sum all the scales together and add it to grayscale value from gamma. The equation we use to sum all the scales is showing below:

$$G'_{L^*} = G_{L^*} + \sum_{i=0}^{n-1} k_i \lambda_i h_i(G_{L^*})$$

Result Discussion



As you can see that the left image is the original image I load into program. The middle image will be the output image that paper authors got. The right one is the result that I have. The paper use the arguments as p = 0.35 k = {1, 1, 1, 0.6}. I use the same argument as paper said and I got the result which is the right image showed above. The result turns out that my result is bit darker than the result they have.



In this result, I also use the same argument as paper mentioned which is p = 0.5 k = {0.3, 0.3, 0, 0}. As you can see the difference between the result I have (right one) and the result paper got(middle one). The result I have is till darker than their result. In addition, my result decrease the local contrast. According to that, the shape the cube and cuboid is little blurter than their result.

Limitation

The paper has some limitations that multi-scale local contrast enhancement reintroduces lost discontinuities only in regions that insufficiently represent original chromatic contrast. This paper address a lot of details of limitation of this algorithm. I will not address those limitation again in my implementation discussion paper. Instead, I will talk about my limitation for implementing this algorithm.

I intend to try only implement the algorithm for image processing instead of applying algorithm implementation for both image and video. The implementation for video and image is similar. If I can figure out image implementation, it will not be so hard to apply algorithm into video (which is bunch of consequence images over time).

Paper provides lots of information for explaining the method, however it doesn't provide enough detail information for how to implement filter. It also lack of the definition of local contrast they use in their algorithm. I had really hard to time find out those information. Their source code is really hard to understand since they do not have enough comment in their program. It is the most frustrated part for this implementation project.

Find out arguments value is another hard part of this implementation. In this paper, they showed several result for different arguments value. However, they do not really explain how those values come from. According to that, all I can do is randomly pick the value to run the program and see the result different. It actually not going so well.

Future work

There is definitely a way to improve this implementation, since I have some of the limitations that I talked about above. As you see, the result I get is different from their result. It probably will be the problem for image filter implantation which is the part that I am not pretty sure about it. In addition, I use the definition of local contrast provided from my professor. I am not sure that is the same definition that this paper use. This is can be another future work I can keep working on.