Project 2: Color Constancy, Shadow Removal, or Intrinsic Imaging

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CS7180: Advanced Perception

Paper: Intrinsic Images by Entropy Minimization

Citation: Graham D. Finlayson1, Mark S. Drew2, and Cheng Lu2

Abstract. We have recreated this paper in python and also took reference from " G.D. Finlayson, S.D. Hordley, and M.S. Drew. Removing shadows from images" for L1-based chromaticity image. We have implemented this paper from scratch and experimented with different chromaticities to see how well each of them works and understand why authors have used the mentioned chromaticity space in their papers.

Introduction and prior work:

The paper aims to remove shadows from a single image without any prior information such as camera calibration, other images taken from a similar camera, and illumination information. The authors have approached this problem in a unique way by employing the entropy minimization technique to determine the invariant image. They have determined the L1 invariant image and reconstructed the shadow-free image from another paper by the same author published in the past "Removing shadows from images". We aim to reconstruct this paper by determining the angle which minimizes the entropy of the projected log chromaticity of an image. inspired by this paper we have compared the results with the method of determining invariant images by geometric mean 2-D chromaticity space, BG, GR, RB, and geometric sum 2-D chromaticity space. Before this paper, the methods for shadow removal depend on the camera calibration or multiple images from the same camera captured under different lighting conditions. But this method aims to remove shadows with just a single image through entropy minimization.

Methods:

1. The first step is to determine the 2D chromaticity image by either projecting it into a 2D plane or diving 2 color channels with the third color channel. As a pre-processing step, we changed the value of all 0 valued pixels to 1.
2. Compute the log chromaticity of the image. by applying a log on each of the pixel values. An observation here is that in computing log chromaticity will lead to a lot of -ve values since the 2D image will have values less than 1. If for some reason we do not want -ve values, we could normalize the 2D chromaticity such that their log values are non-negative. We did not see it to be a necessary step so we did not normalize it.
3. Project the log chromaticity values on the axis with angles from 0 to 180.
4. We need to exclude the outliers, otherwise, we can expect the noise to possibly be enhanced. So we apply the 6-sigma approach to eliminate the outliers. Compute the mean and standard deviation of the resulting projected image. Determine the pixels within a range of 3 * std_dev. This will ensure the pixel values are within the 5 to 95 percentile range.
5. Compute the histogram of the resulting pixels with the bin width mentioned in the paper: bin_size = 3.5*Std_dev*img_shape**(-1/3)
6. Compute the entropy using the Shannon entropy formula and determine the angle at which there is minimum entropy.
7. To find the invariant image, project the log chromaticity image with the obtained minimum entropy angle which is the invariant angle.

Results:

We performed tests using various chromaticity spaces such as:

1. Single color channel (B/G/R)
2. Arithmetic mean (B + G + R) /3
3. Geometric mean (B * G * R) ^ 1/3

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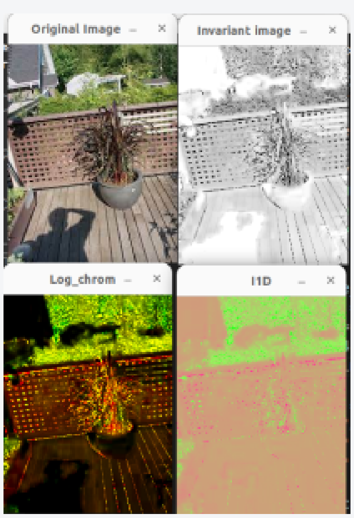
<td>
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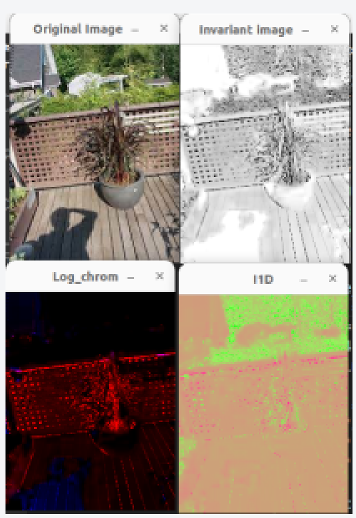
<td>
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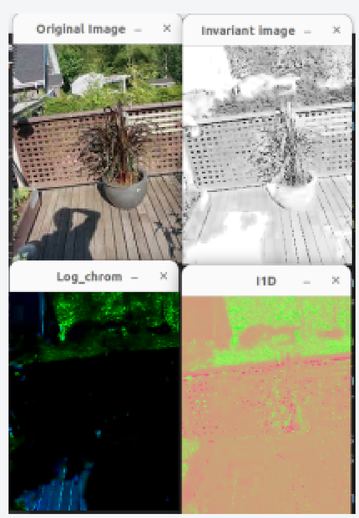
<td>
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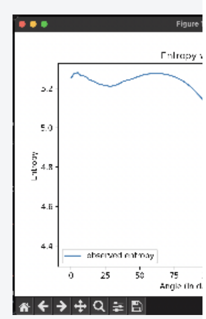
<td>

Minimum Entropy: 3.8
Invariant Angle (degrees): 237.000000
Minimum entropy angl</td>
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<tr>
<td>B</td>
<td>G</td>
<td>R</td>
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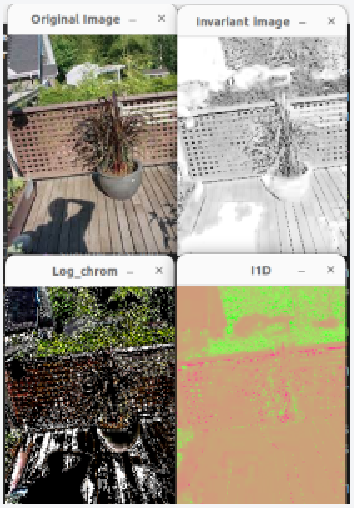
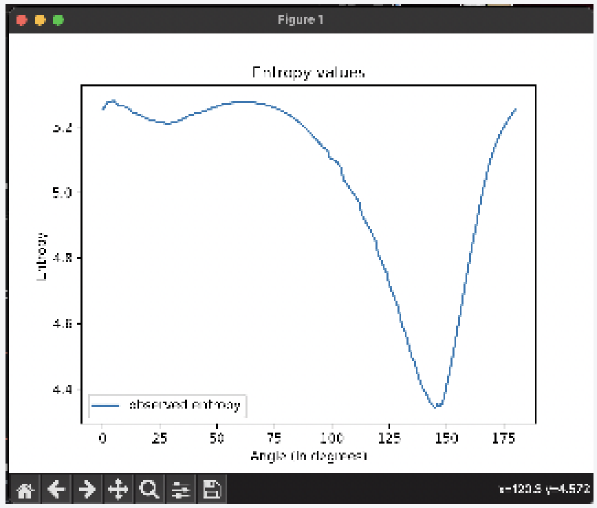
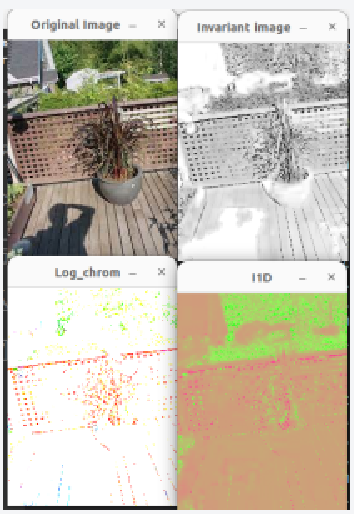
Arithmetic Mean:

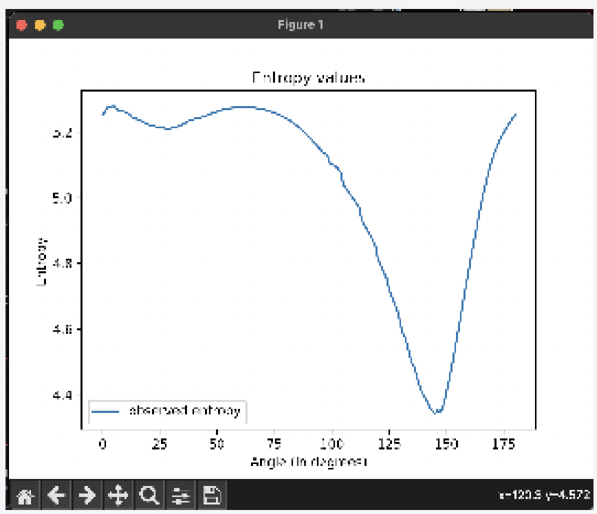




Minimum Entropy: 3.841431562767423
Invariant Angle (degrees): 237.00000000000003
Minimum entropy angle(degrees): 147.0

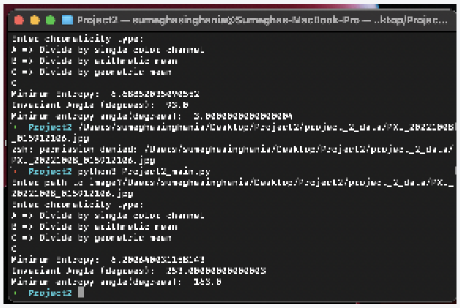
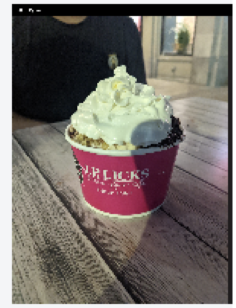
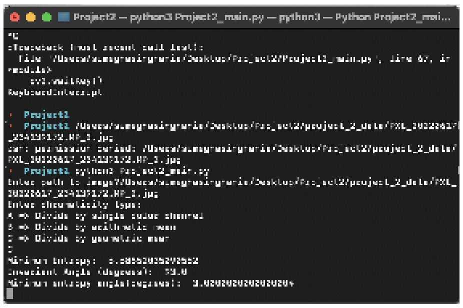
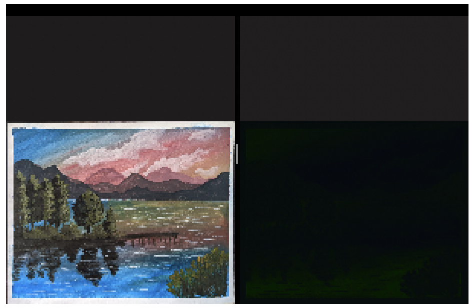
Geometric Mean:





Minimum Entropy: 4.340673605036976
Invariant Angle (degrees): 235.00000000000003
Minimum entropy angle(degrees): 145.0

Other results

The method performs really well in determining the L1 invariance and in the painting picture the L1 invariance is too low. We infer that it has artificial shadows in the picture, the method is failing in this case. However, if you can see if you increase the brightness, it has some greenish texture. So it it trying to produce something but definitely failing in this case of painting.

Reflection and acknowledgments:

It was a great learning curve while working on this project. We had a depth understanding of the illumination direction and invariant images. It was fun understanding entropy minimization and implementing it in practice. We also brainstormed about what kind of experiments we could do to evaluate our method which simulates the actual task while writing papers where authors design experiments to test their work. Overall it was a great learning curve working on this project and I understand how advanced the State of the art shadow removal techniques using neural networks are. We have come a long way!