EECS 4422 Assignment 1 Report

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September 2018

1 Fitting a Point to lines and a line to points

1.1 (a)

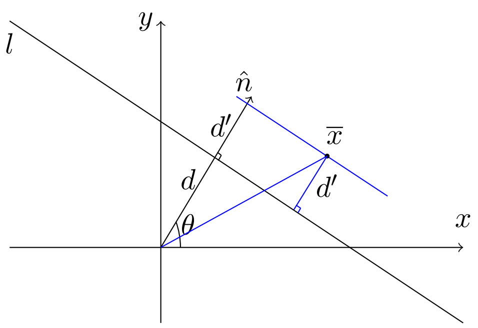


Figure 1: Modified normalized form of 2D line

With an arbitrary point $\overline{x}$, first draw a line through the point that parallel to line l, d' is the distance from $\overline{x}$ to line l, then $d' + d$ will be equal to the projection of the line from origin to $\overline{x}$ onto $\hat{n}$.

$$\begin{aligned}
d + d' &= \overline{x} \cdot \hat{n} \\
d' &= \overline{x} \cdot \hat{n} - d \\
d' &= \begin{bmatrix} x \\ y \end{bmatrix} \cdot \begin{bmatrix} \hat{n}_x \\ \hat{n}_y \end{bmatrix} - d \\
d' &= x \cdot \hat{n}_x + y \cdot \hat{n}_y - d \\
d' &= \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} \cdot \begin{bmatrix} \hat{n}_x \\ \hat{n}_y \\ -d \end{bmatrix} \\
d' &= \overline{x} \cdot l
\end{aligned} \tag{1}$$

1.2 (b)

$$
\begin{aligned}
D &= \sum_i (\overline{x} \cdot l_i)^2 \\
&= \sum_i (x \cdot \hat{n}_i - d_i)^2 \\
&= \sum_i \left(x^T \hat{n}_i - d_i\right)^2 \\
&= \sum_i \left((x^T \hat{n}_i)^2 - 2d_i x^T \hat{n}_i + {d_i}^2\right) \\
&= \sum_i \left(x^T \hat{n}_i \hat{n}_i^T x - 2d_i x^T \hat{n}_i + {d_i}^2\right)
\end{aligned} \tag{2}
$$

$$
\begin{aligned}
\frac{\partial D}{\partial x^T} = \sum_i \left(2\hat{n}_i \hat{n}_i^T x - 2d_i \hat{n}_i\right) &= 0 \\
\sum_i \left((\hat{n}_i \hat{n}_i^T)x - d_i \hat{n}_i\right) &= 0 \\
\sum_i (\hat{n}_i \hat{n}_i^T)x - \sum_i d_i \hat{n}_i &= 0 \\
\sum_i (\hat{n}_i \hat{n}_i^T)x &= \sum_i d_i \hat{n}_i \\
x &= \sum_i (\hat{n}_i \hat{n}_i^T)^{-1} \sum_i d_i \hat{n}_i
\end{aligned} \tag{3}
$$

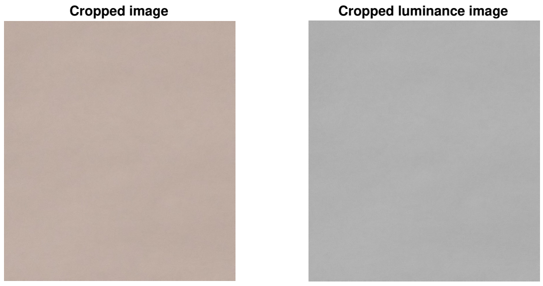
1.3 (c)

See in MATLAB files.

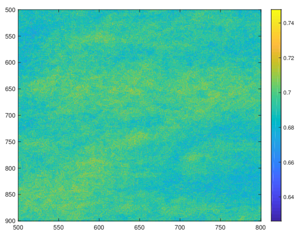
2 Sensor Noise

2.1 Method 1

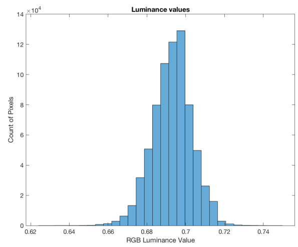
From both the cropped images [Figure 2,3], the illuminance of the region is slightly different, it appears more obvious when we plot image with scaled colors. The distribution of both histograms are Gaussian distribution. The normalized standard deviation of the high luminance image and low luminance image are, 0.0142 and 0.0173, respectively. The difference between the values are very small. The normalized noise level seems independent upon the amount of light in the room. The image has merely more noise when the light is off, but the time we took pictures was the afternoon and the wall is beside a large window,



(a) images



(b) imagesc



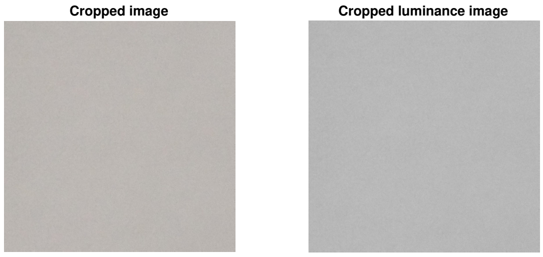
(c) Histogram

Figure 2: Image with high illuminance

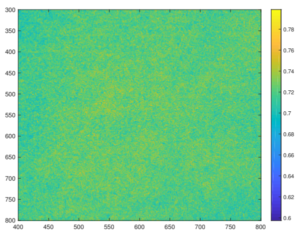
the most amount of light on the wall were from the sun. That explains why the noise level isn't affected much when we turn off the light. The potential flaw with this method is the two images are under different light condition and the shot noise and read noise increase as the lightness is reduced, the result will be inaccurate for estimating sensor noise.

2.2 Method 2

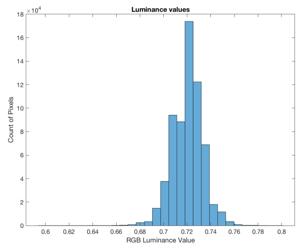
From the luminance difference image, I think there was no any movement because the noise are distributed randomly, so the difference may not be very close to 0 [Figure 4]. The distribution of the histogram of illuminance difference is Gaussian distribution, it's same type of distribution compare with Method 1. They should be similar because if two datasets are belong to same type of distribution, then their subtraction or addition should remain the same distribution type. The normalized standard deviation of this luminance image is -1.0566. Two images taken back-to-back indicates their light condition are identical, so the noise level is not depend on the amount of light in the room. The potential flaw of this



(a) images



(b) imagesc



(c) Histogram

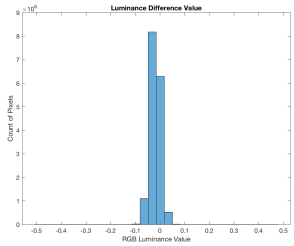
Figure 3: Image with low illuminance

method is the subtraction of two images may enlarge the noise level. I think the Method 1 is more accurate since the noise caused by the illuminance condition is the noticeable and it can be minimized by make the illuminance level close as possible, but in the Method 2 the noise level is enlarged in the calculation and unmovable from the algorithm.

3 White Balance

For indoor image with single lighting source, the image after white balancing looks more white. For outdoor, the image after white balancing doesn't look white but gray due to the lack of illumination and color reflection from other objects [Figure 5]. The image after white balancing image looks better for indoor because it looks more natural. The image before white balancing looks better for outdoor since it has less noise and the color is more smooth.

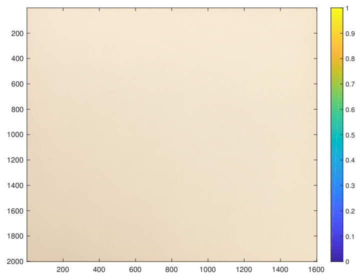
(a)



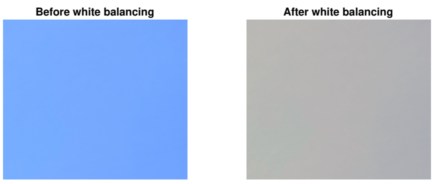
(b)

Figure 4: Luminance difference image and histogram

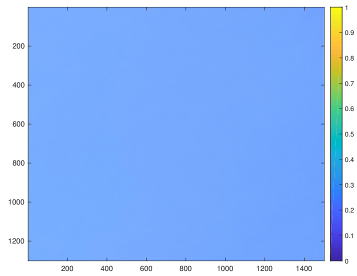
(a) indoor image



(b)



(c) outdoor image



(d)

Figure 5: Indoor and outdoor images