PROJECT REPORT 1
IMAGE RELIGHTING

CSE264 - COMPUTER VISION

KEVAL NAGDA

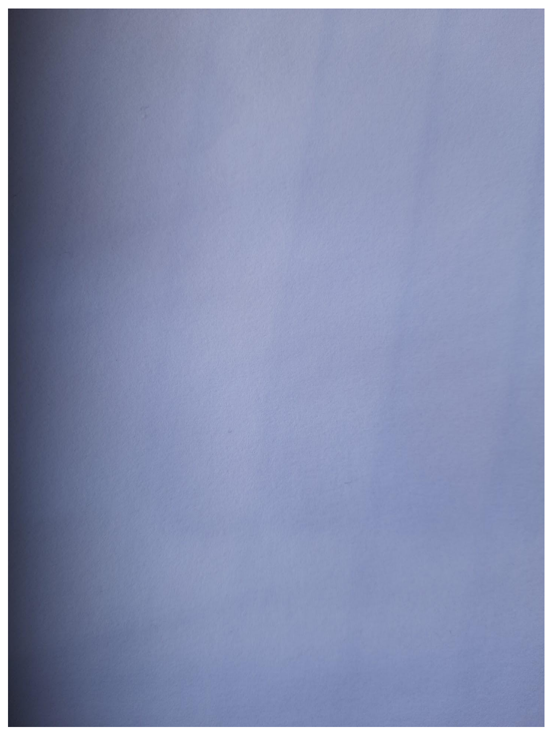
PART 1 - CAMERA RADIOMETRIC CALIBRATION

The first step was to perform camera radiometric calibration, for which I use the Camera FV-5 Lite android application to click pictures. I fix the White Balance (WB) of the camera and set the gain (ISO) to 100. Next step involved fixing my camera on a stand and clicking pictures of a white sheet of paper with different exposure times ranging from 1/10 s to 1/250 s. Below are the images (along with their exposure times) of the white sheet of paper that I clicked:

Fixed Gain (ISO): 100

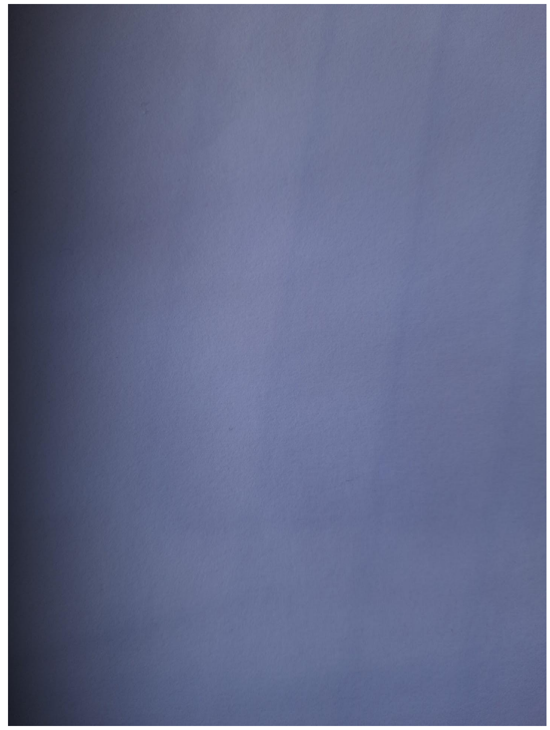
T = 1/10 s

T = 1/13 s

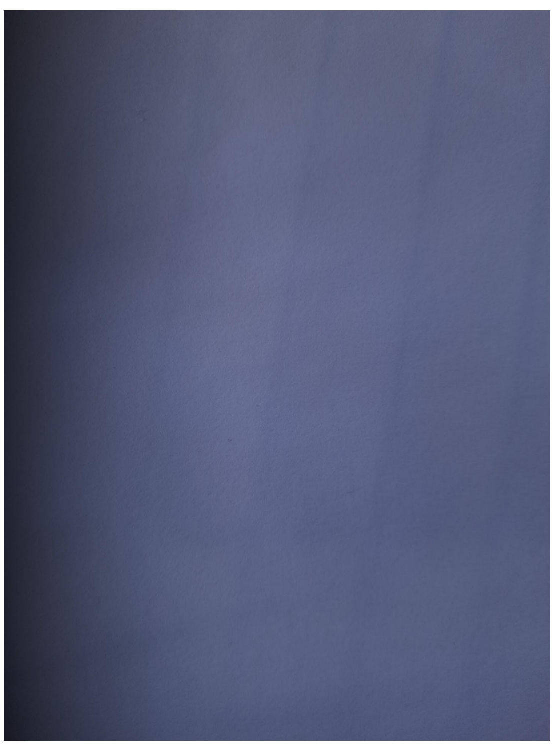


T = 1/15 s

T = 1/20 s



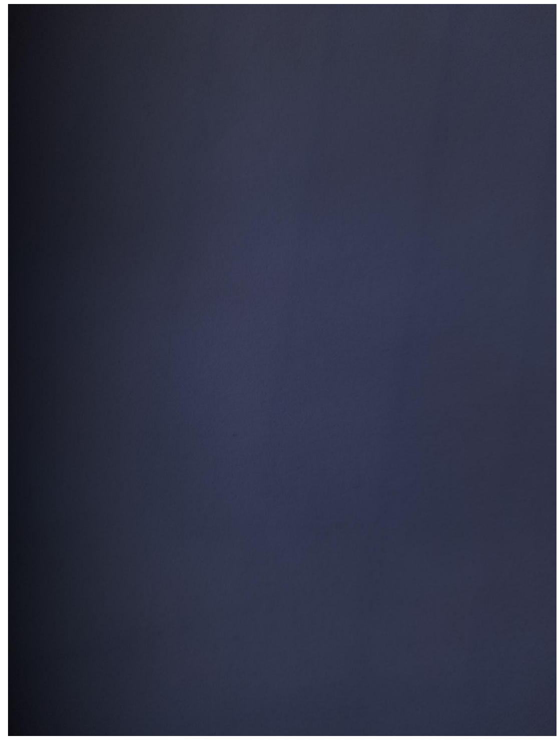
T = 1/25 s



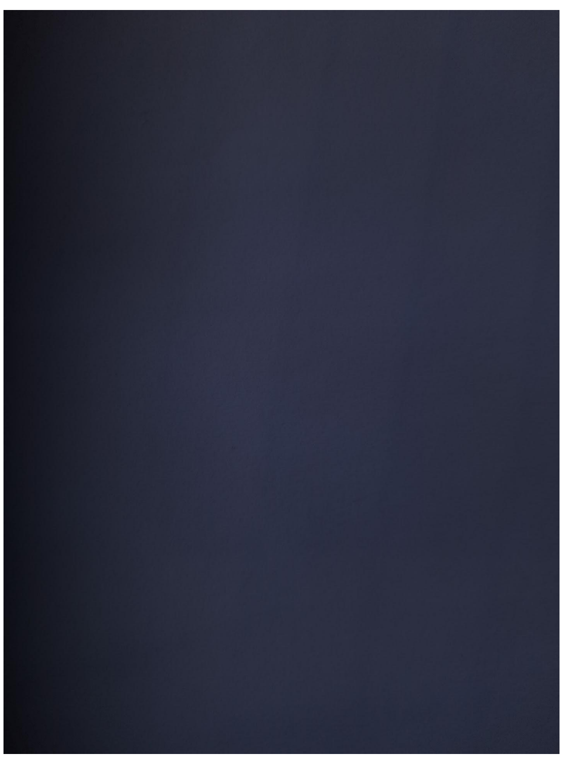
T = 1/30 s

T = 1/40 s

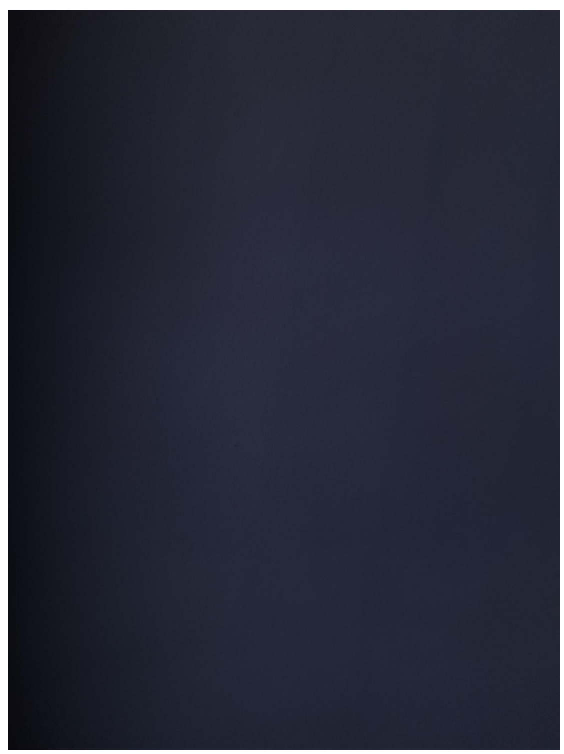
T = 1/50 s



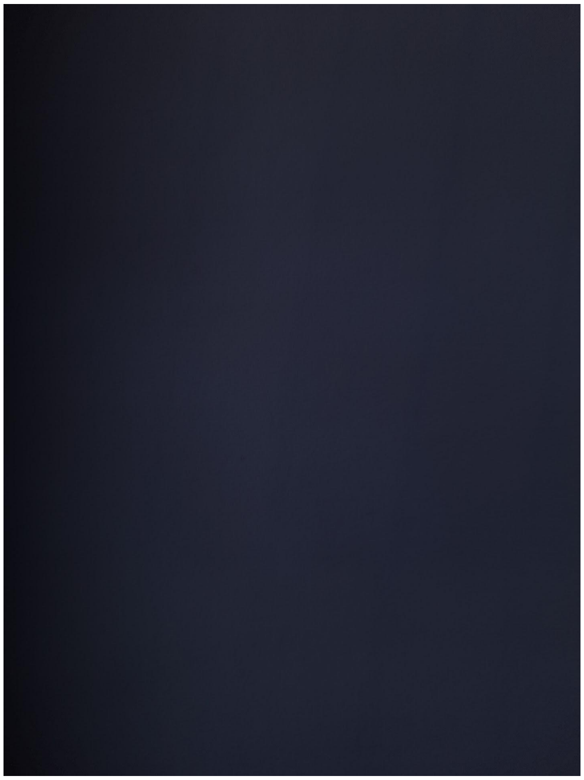
T = 1/60 s



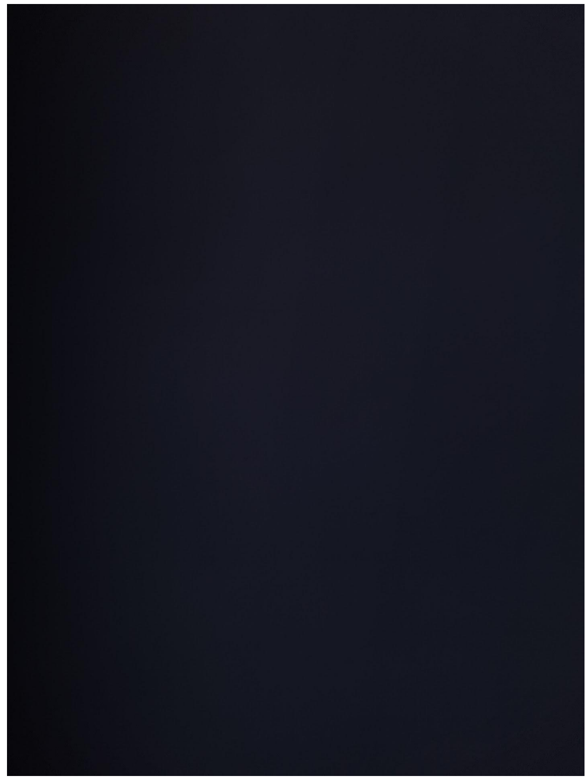
T = 1/80 s



T = 1/100 s

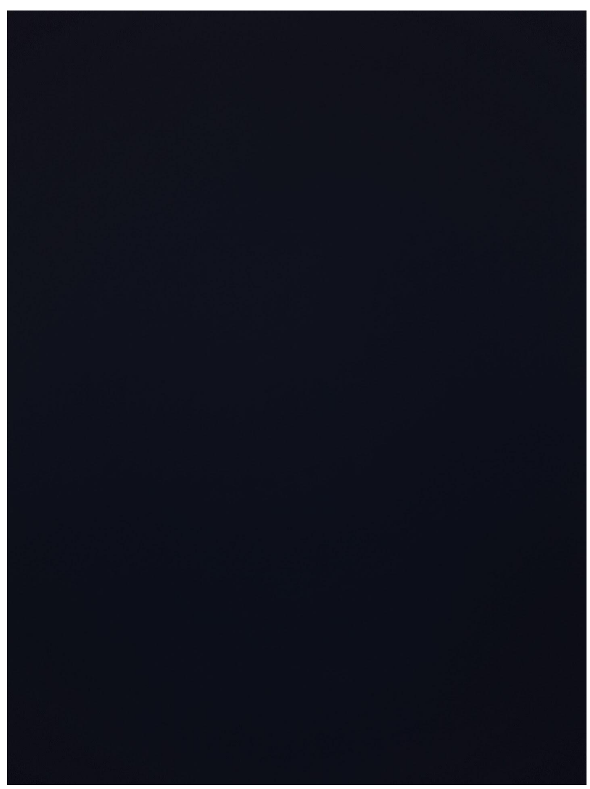


T = 1/160 s



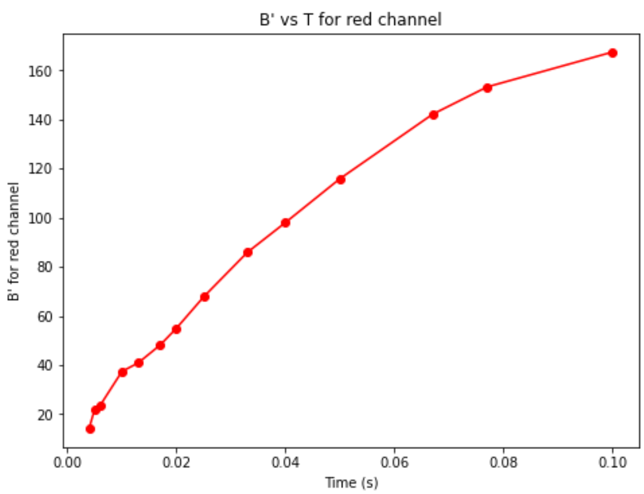
T = 1/200 s

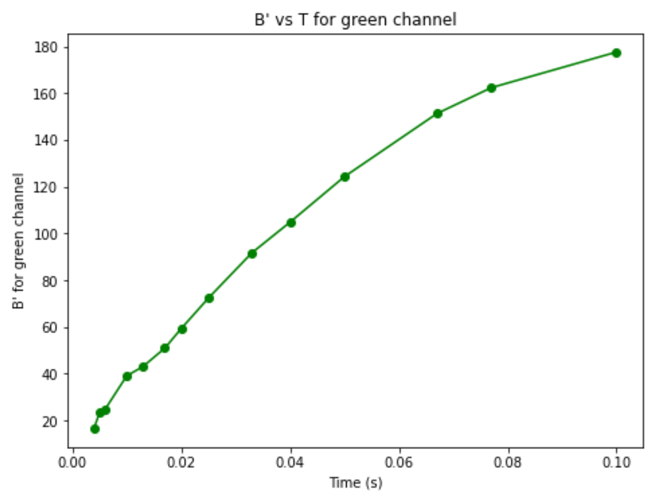
T = 1/250 s

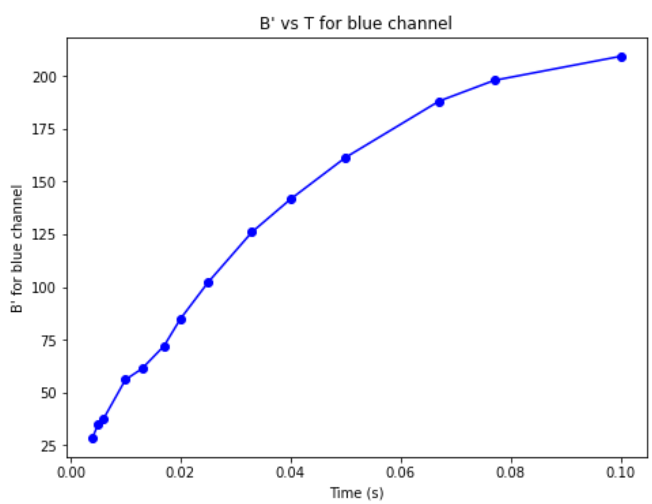


Once I have all the images i.e., set of pixel values ($B_j'T_1$, $B_j'T_1$, …, $B_j'T_N$) where (T_1, T_2, …, T_N) and j is the color channel, I crop 100x100 patches from all the images at the center and discard all the pixel values that are >255.

Below is the plot of B_j’ (red, green and blue channel) measured as a function of T for all the images:

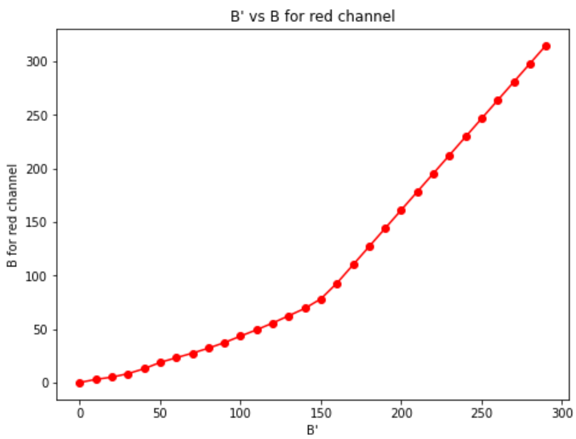


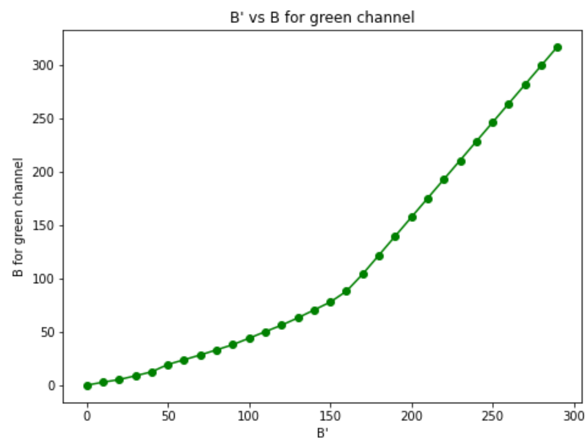


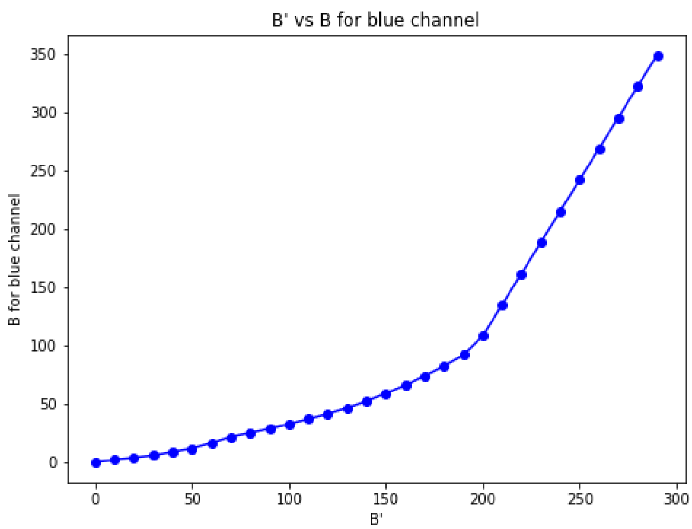


Now, using the bilinear interpolation method I estimated the intermediate values for all the images. We know that $B_j = f_j^{-1}(B_j')$ so we find the function to convert the values obtained to get B_{real}.

Below is the graph for function $B_j = f_j^{-1}(B_j')$ obtained for each channel by passing in the values of the images that I clicked:







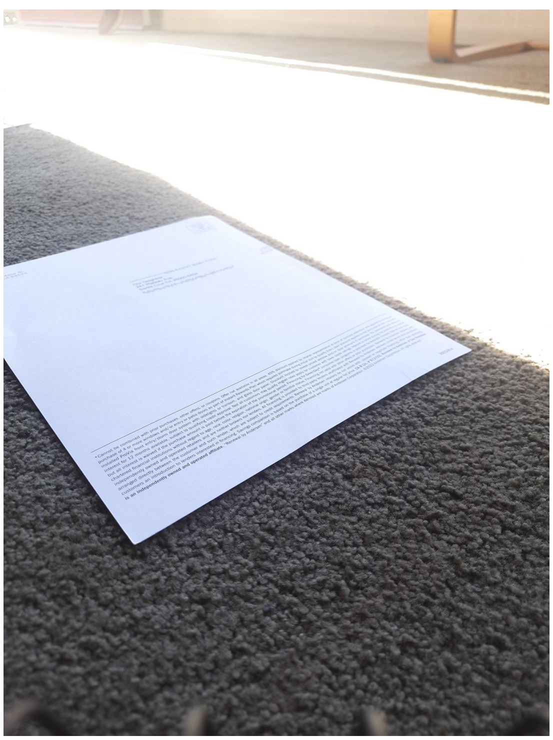
PART 2 - ACQUIRE A PICTURE STACK

In this part of the step, we place a sheet of paper with some text on it in a dark shaded area. The sheet is placed in such a way that there is a sunlit area next to it to capture the contrast.

All the images are linearized using the $B_j = f_j^{-1}(B_j')$ functional relation we obtained in the previous step.

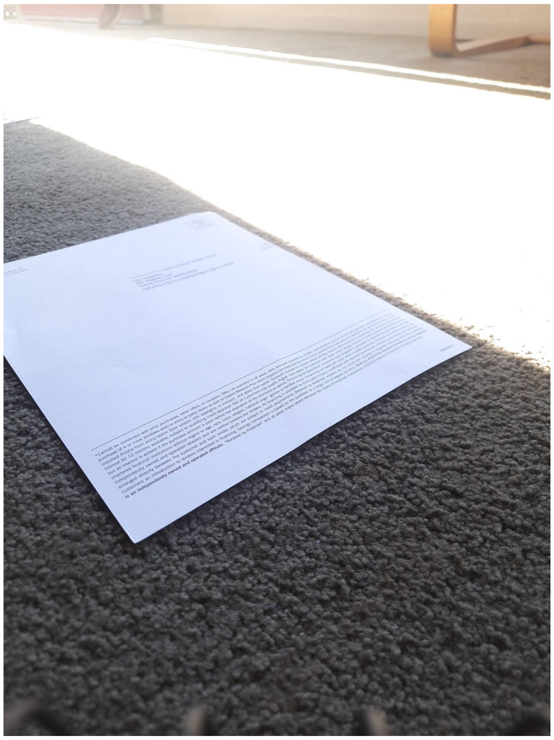
Below is a list of all the images that I clicked with the exposure times mentioned along with the linearized images for comparison:

Original image at T = 1/10 s



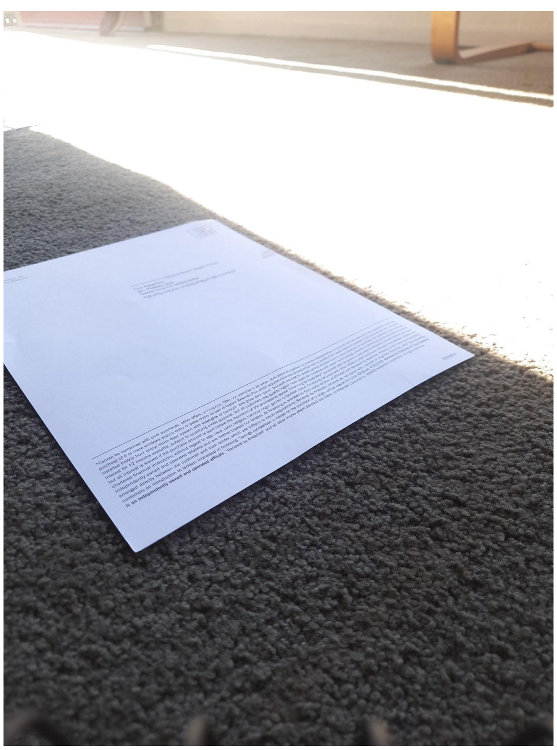
Linearized image at T = 1/10 s

Original image at T = 1/11 s

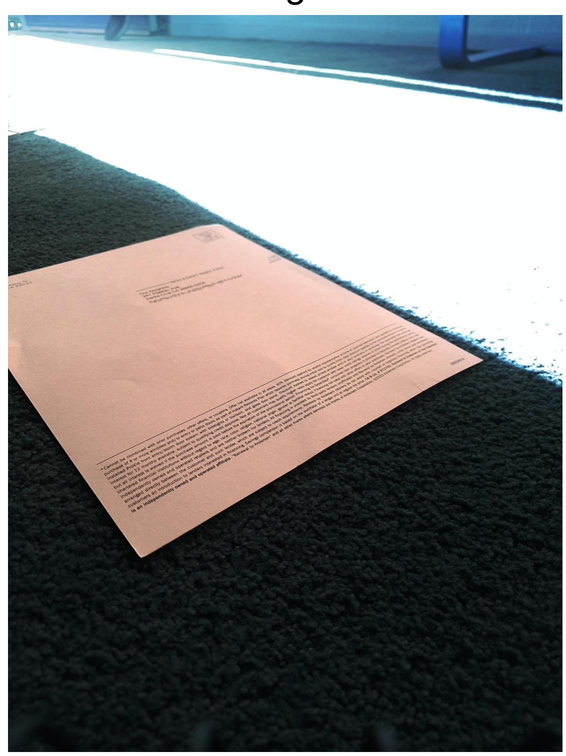


Linearized image at T = 1/11 s

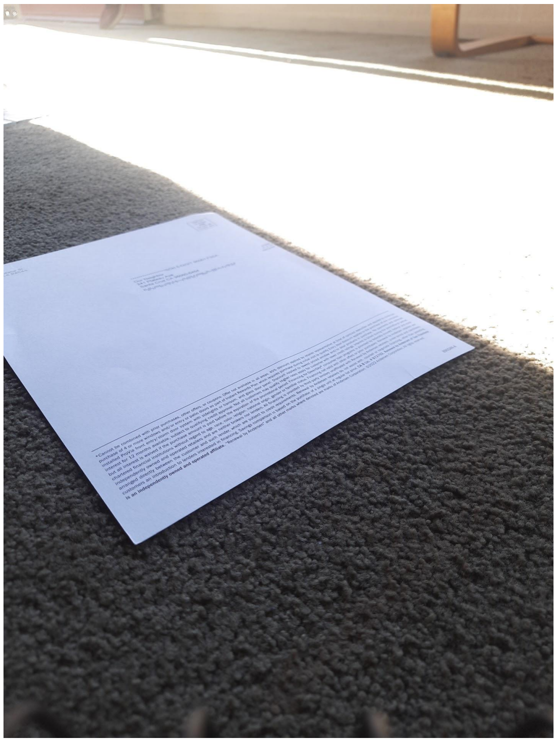
Original image at T = 1/13 s



Linearized image at T = 1/13 s

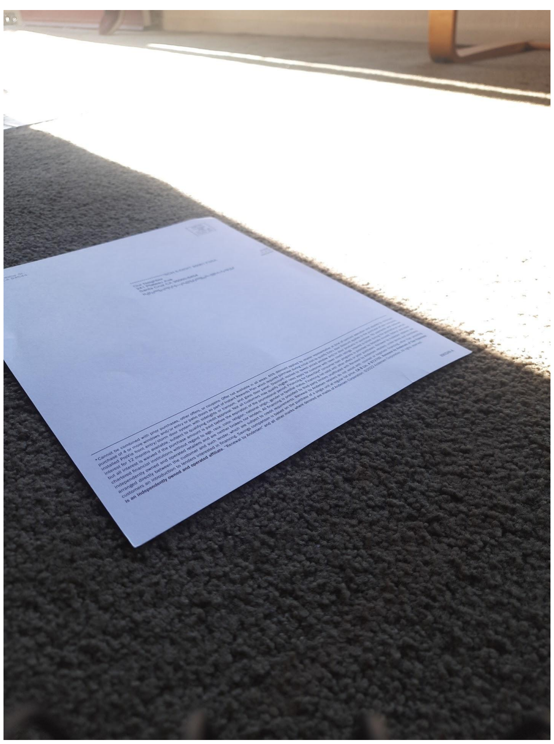


Original image at T = 1/15 s

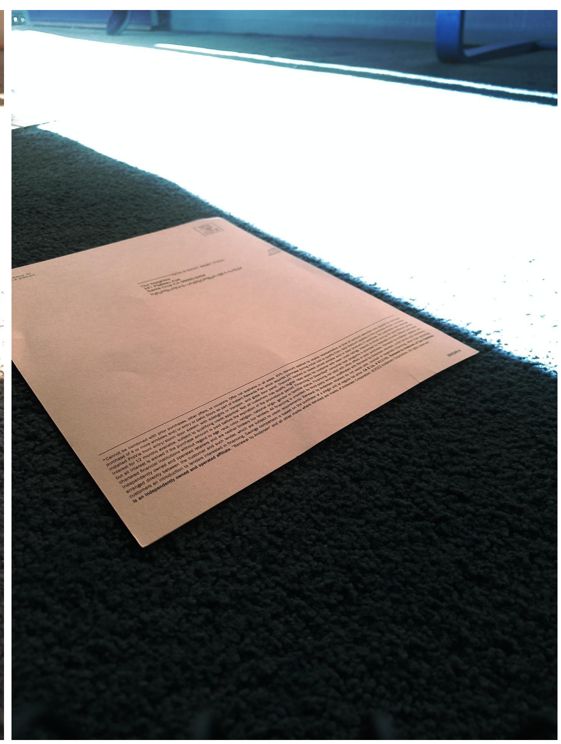


Linearized image at T = 1/15 s

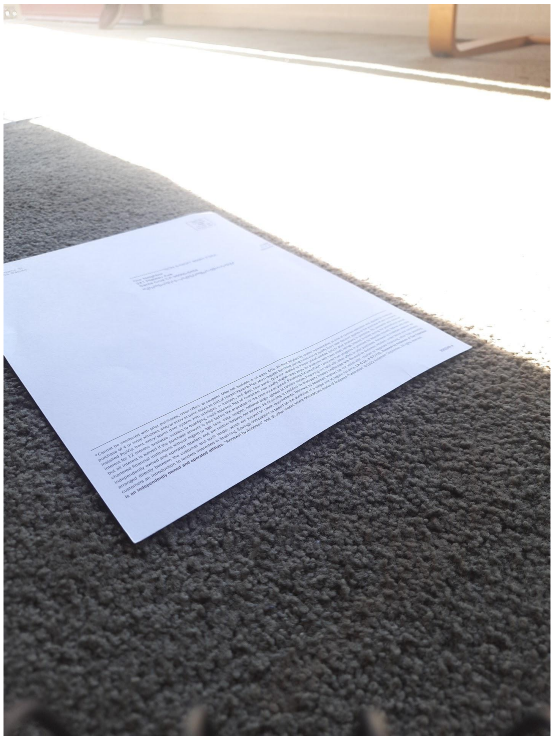
Original image at T = 1/20 s



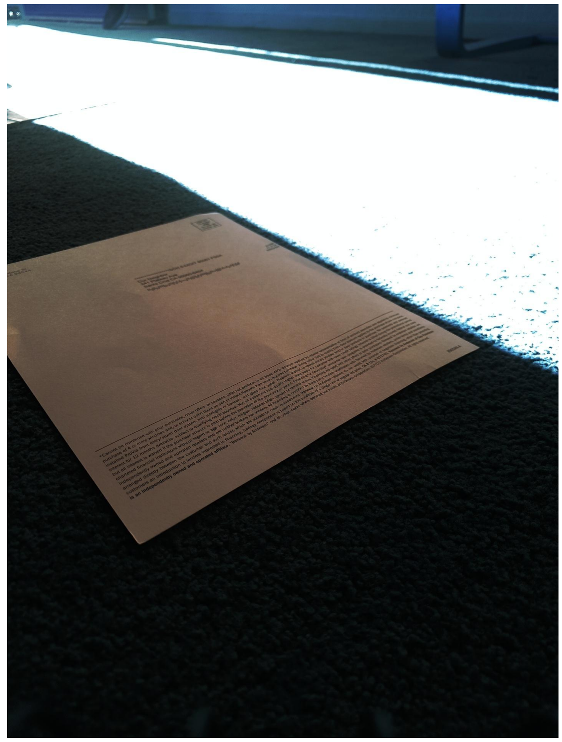
Linearized image at T = 1/20 s



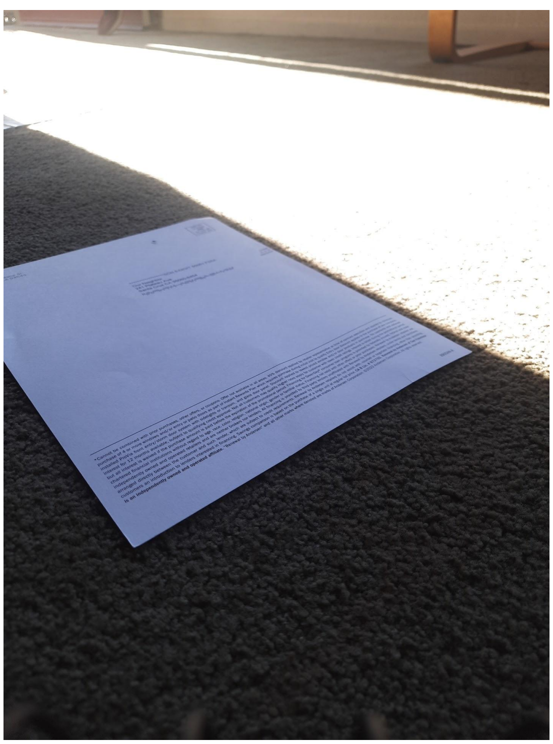
Original image at T = 1/25 s



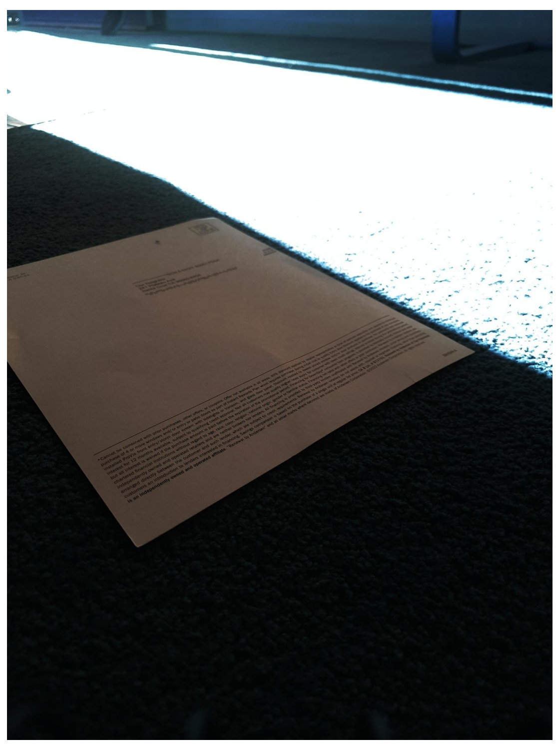
Linearized image at T = 1/25 s



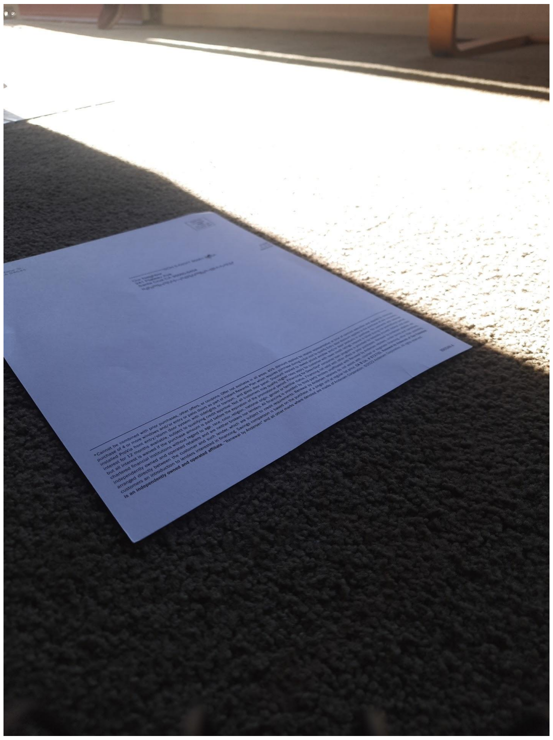
Original image at T = 1/30 s



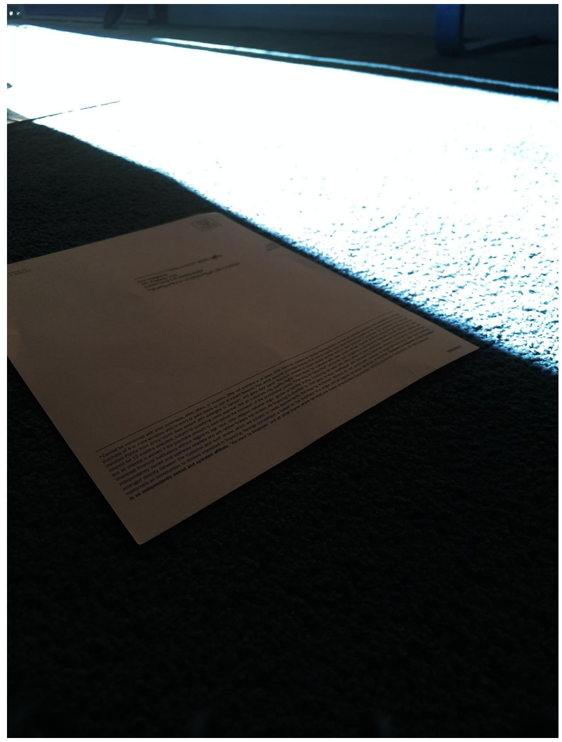
Linearized image at T = 1/30 s



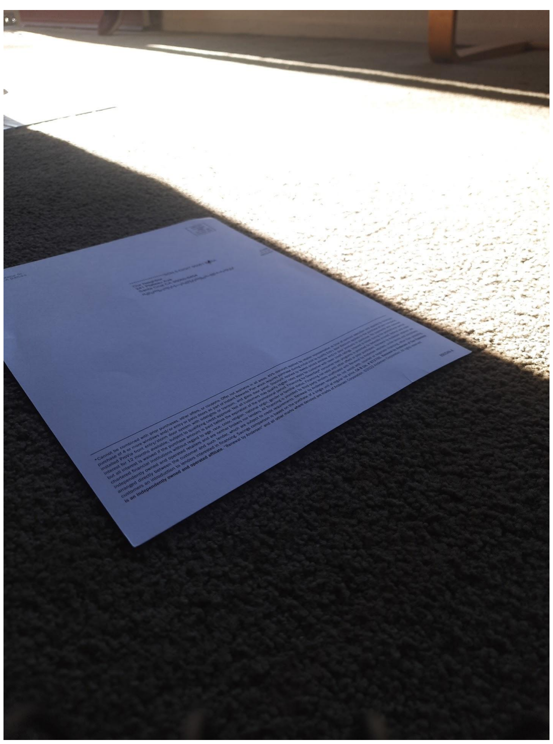
Original image at T = 1/40 s



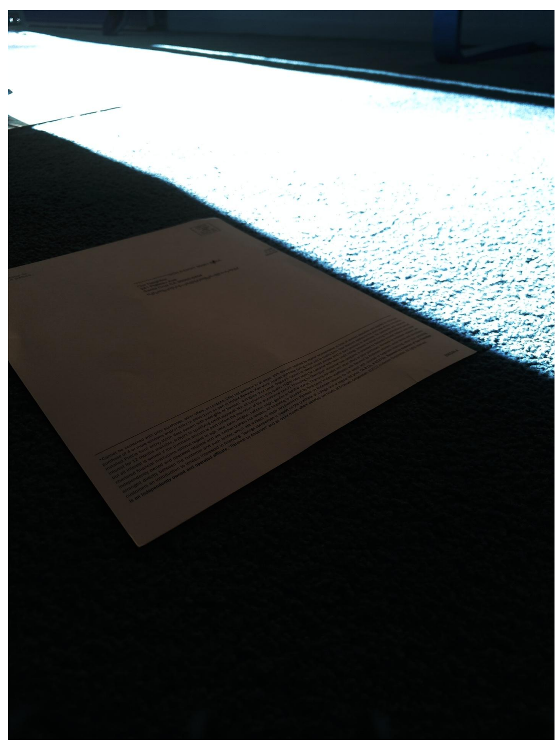
Linearized image at T = 1/40 s



Original image at T = 1/50 s

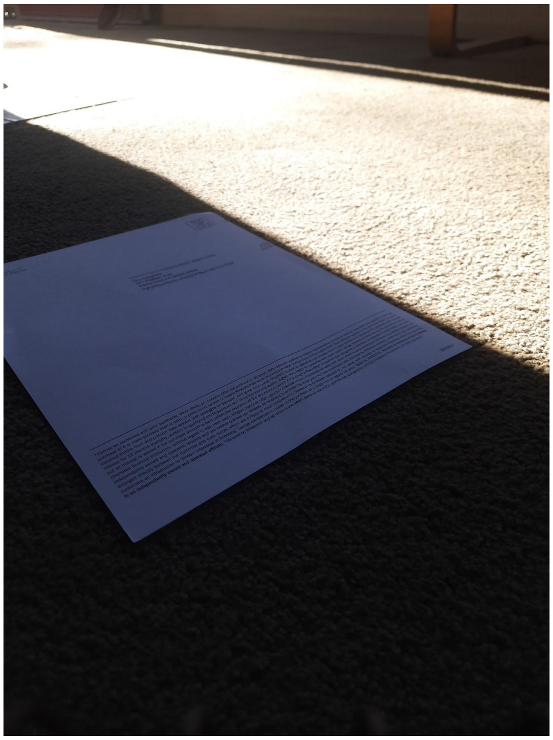


Linearized image at T = 1/50 s

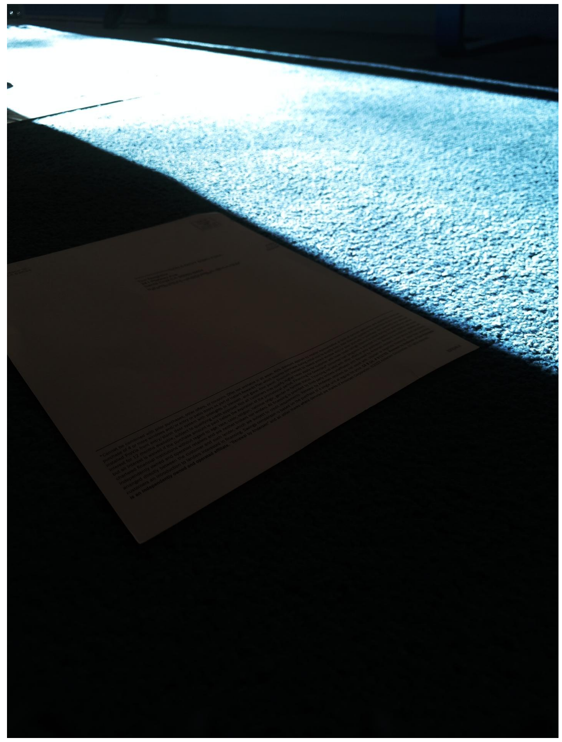


This image is selected as $\bar{T}$ (correctly exposed to the right)

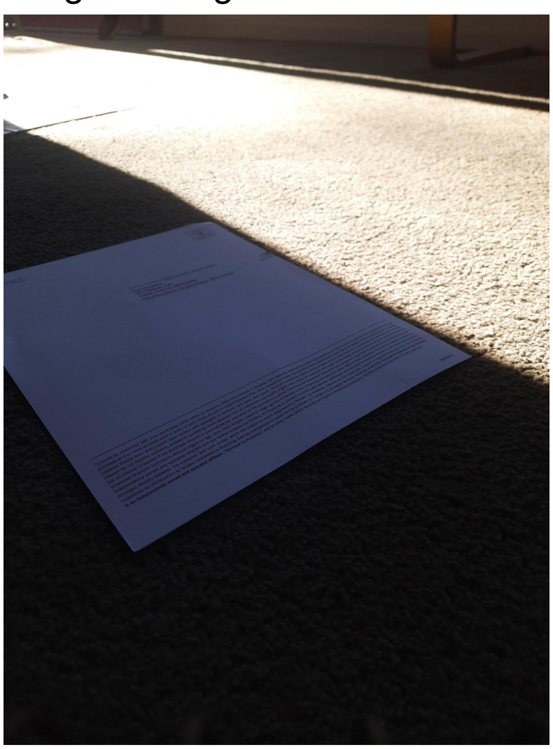
Original image at T = 1/80 s



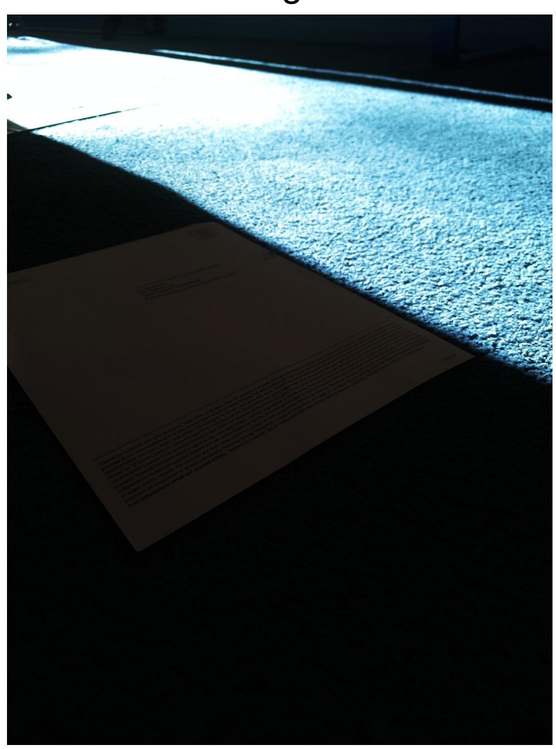
Linearized image at T = 1/80 s



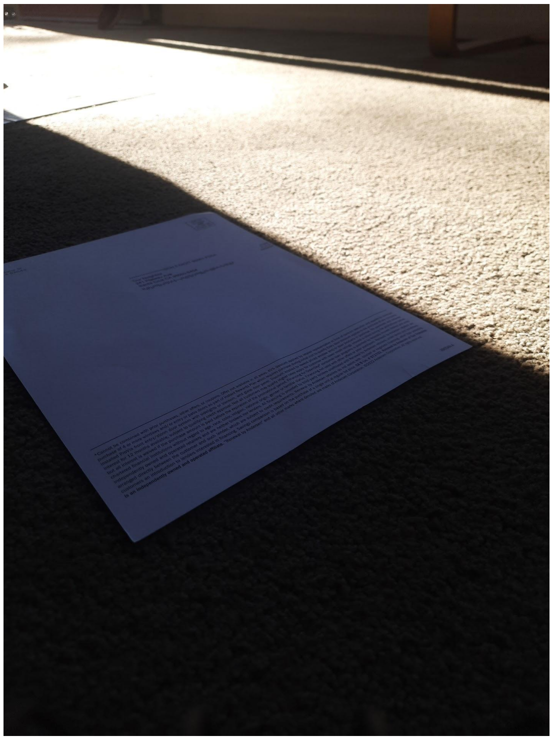
Original image at T = 1/90 s



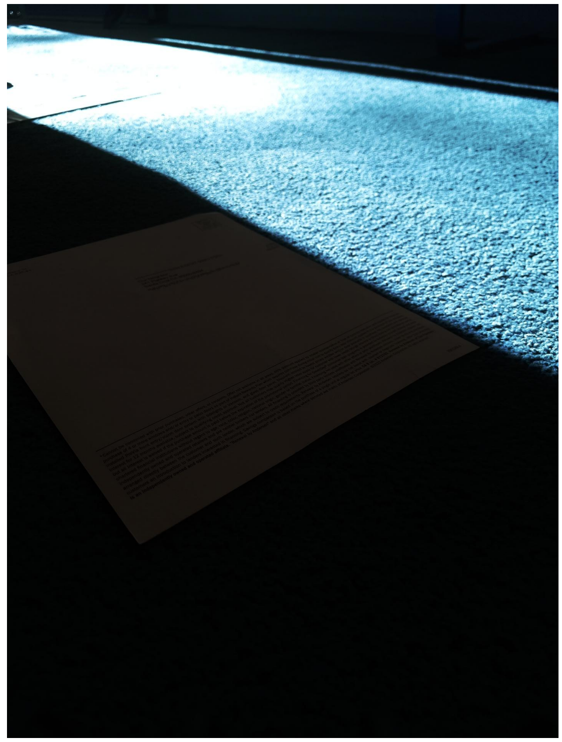
Linearized image at T = 1/90 s



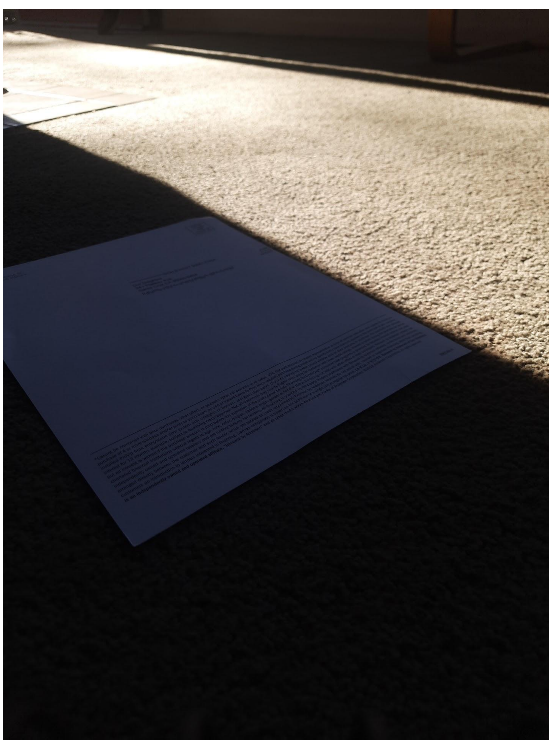
Original image at T = 1/100 s



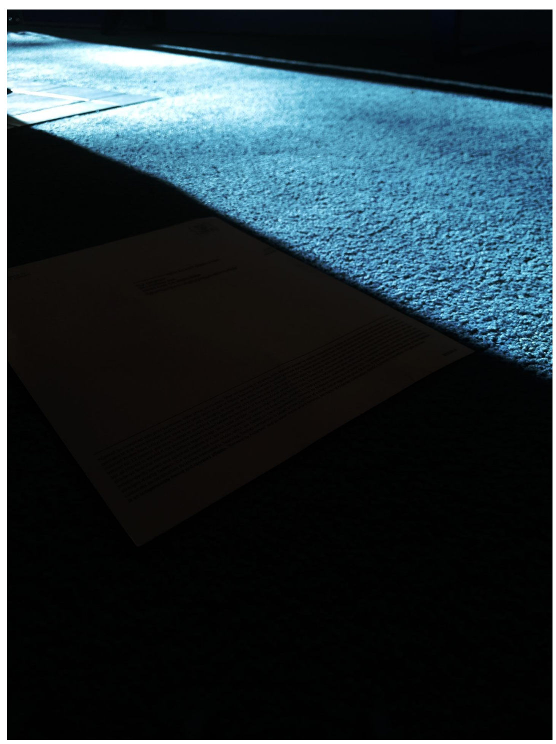
Linearized image at T = 1/100 s



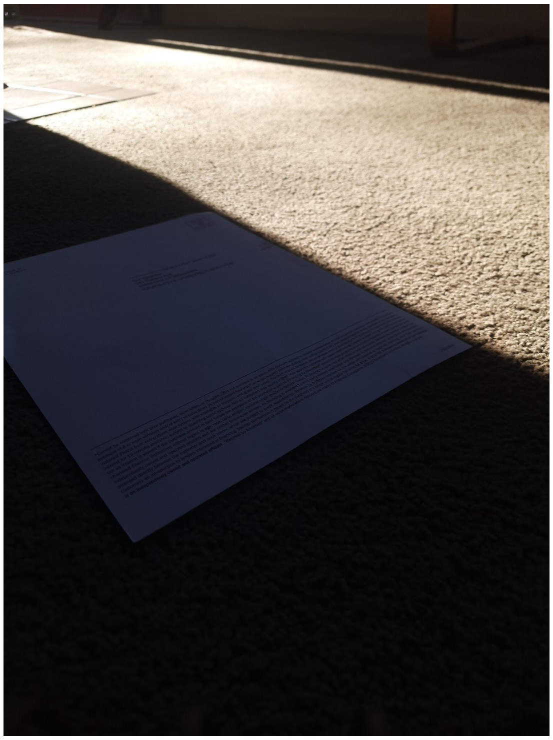
Original image at T = 1/160 s



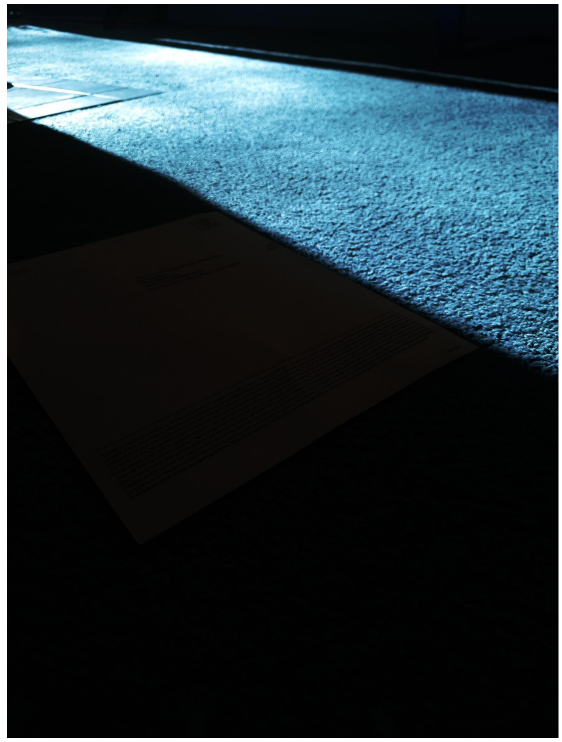
Linearized image at T = 1/160 s



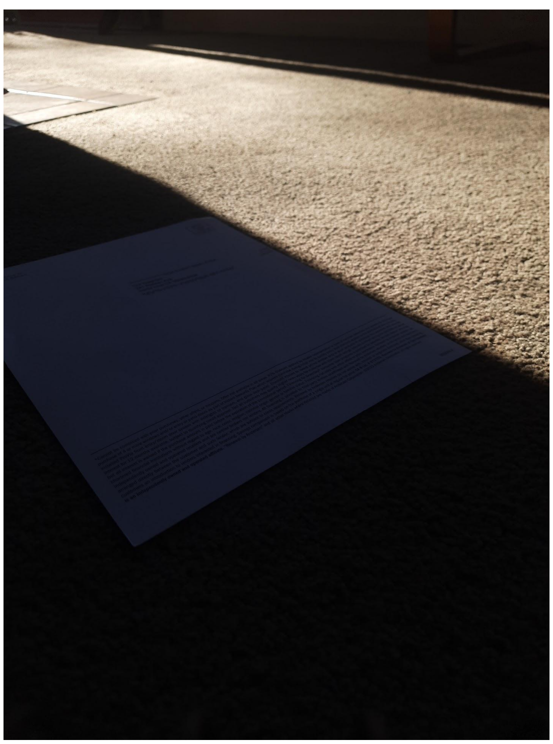
Original image at T = 1/200 s



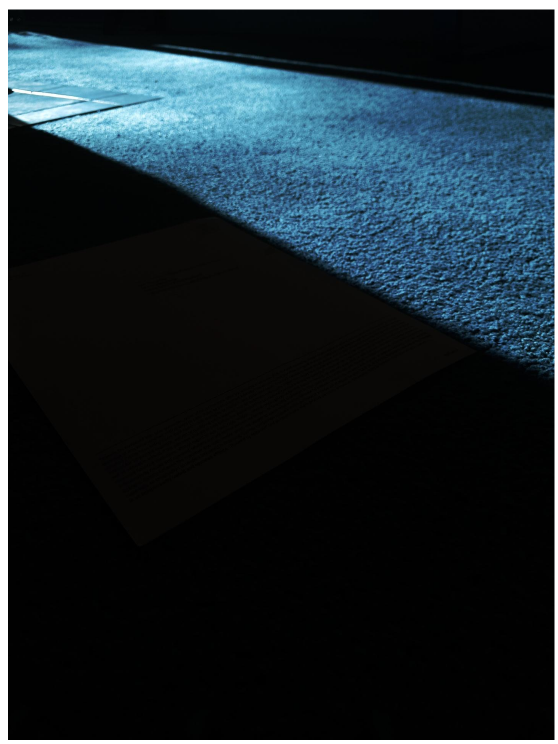
Linearized image at T = 1/200 s



Original image at T = 1/250 s

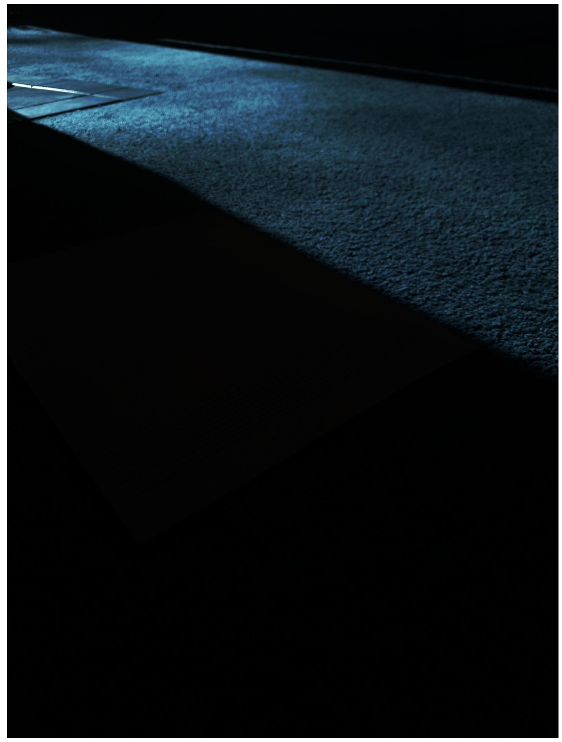


Linearized image at T = 1/250 s



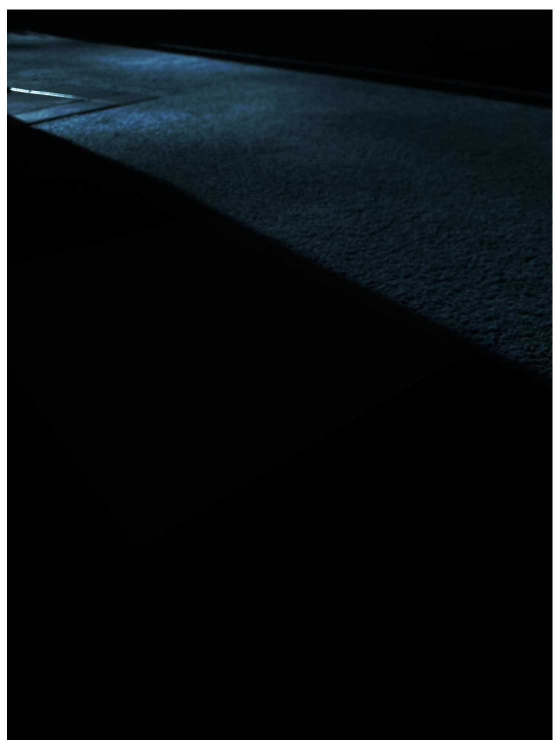
Original image at T = 1/500 s

Linearized image at T = 1/500 s

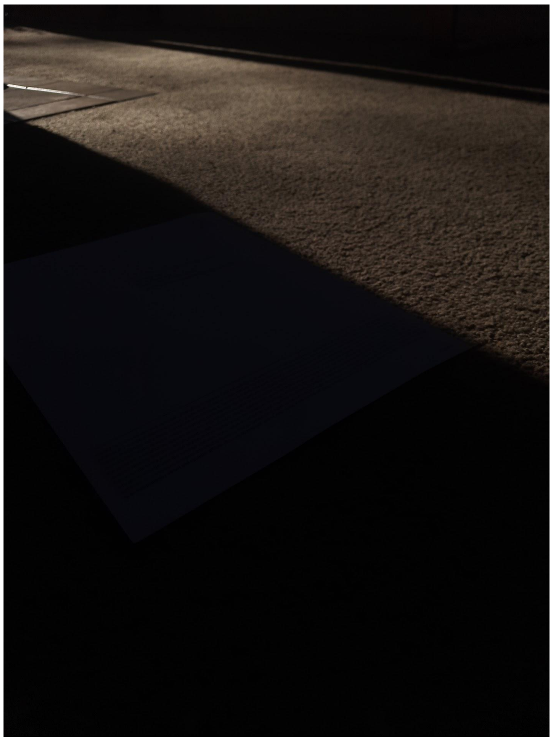


Original image at T = 1/800 s

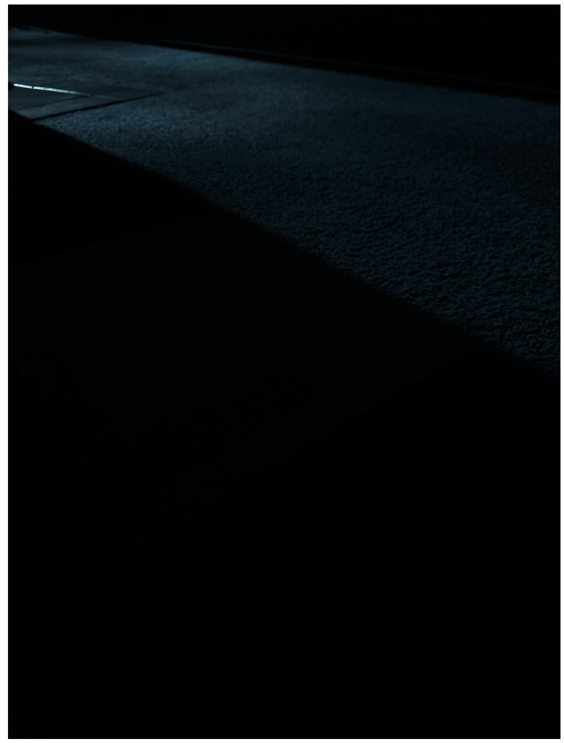
Linearized image at T = 1/800 s



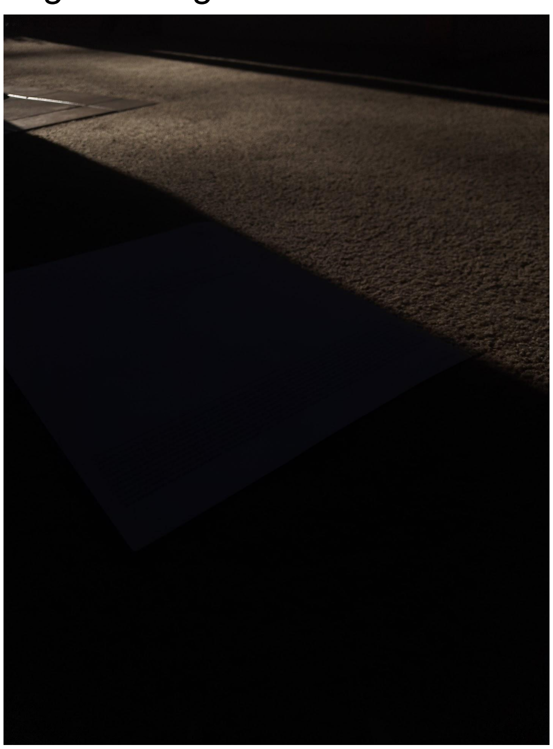
Original image at T = 1/1250 s



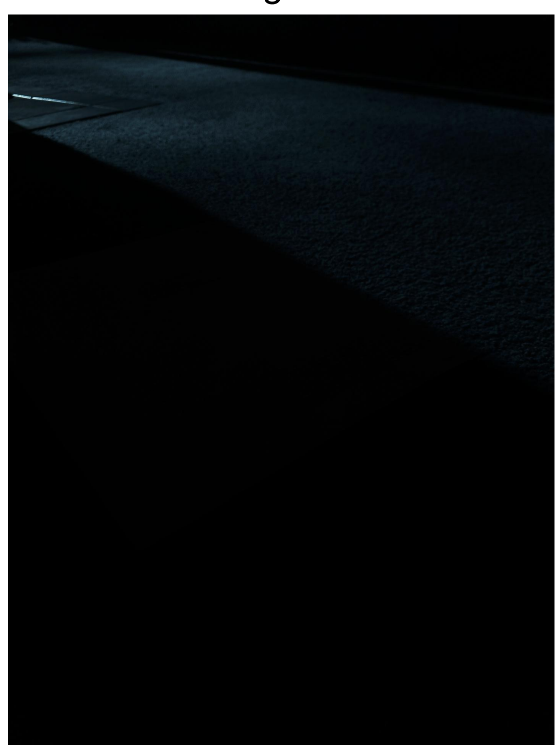
Linearized image at T = 1/1250 s



Original image at T = 1/1500 s

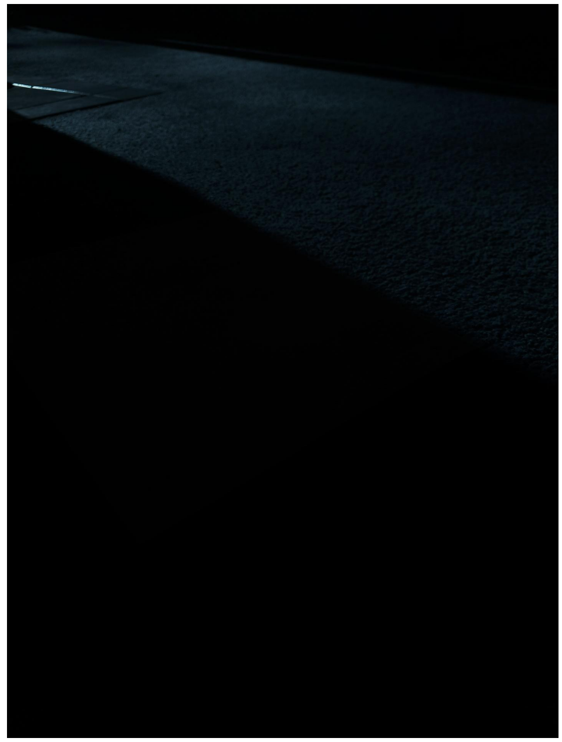


Linearized image at T = 1/1500 s

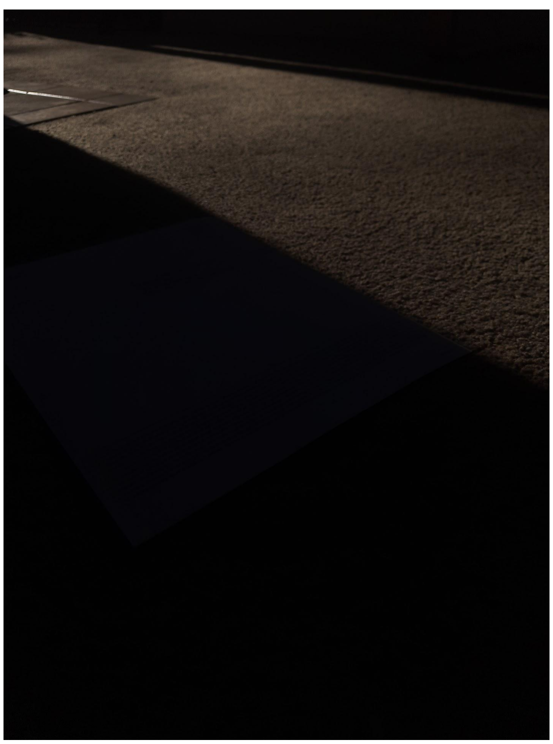


Original image at T = 1/1600 s

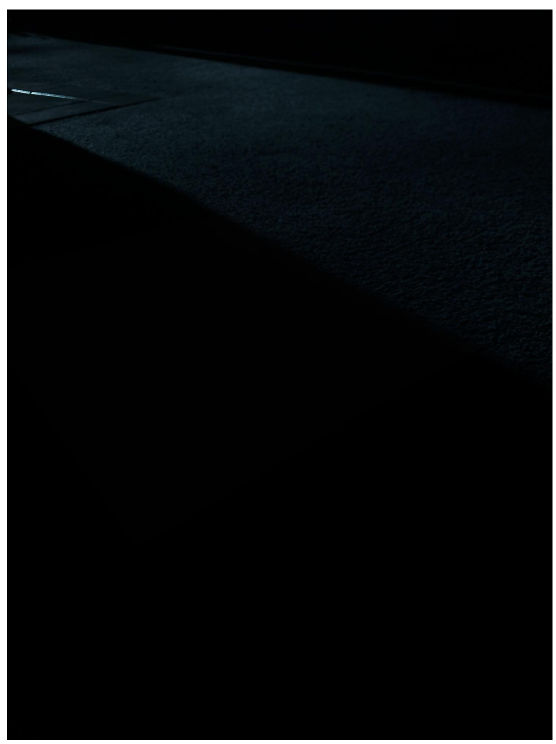
Linearized image at T = 1/1600 s



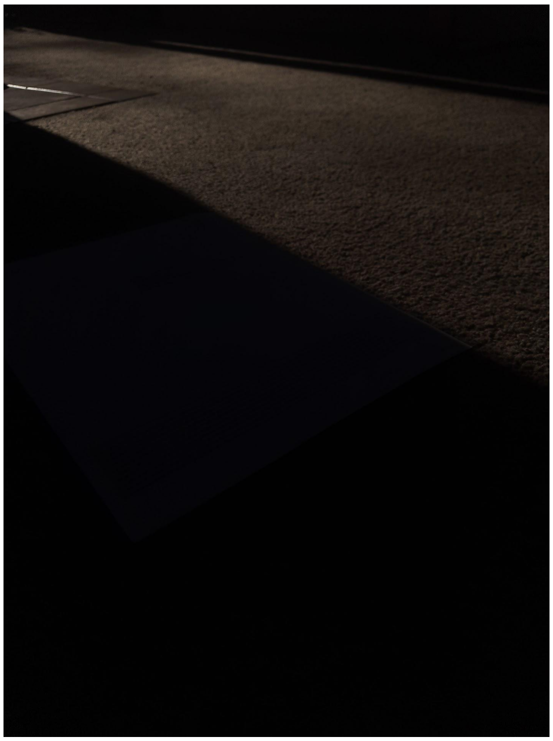
Original image at T = 1/2000 s



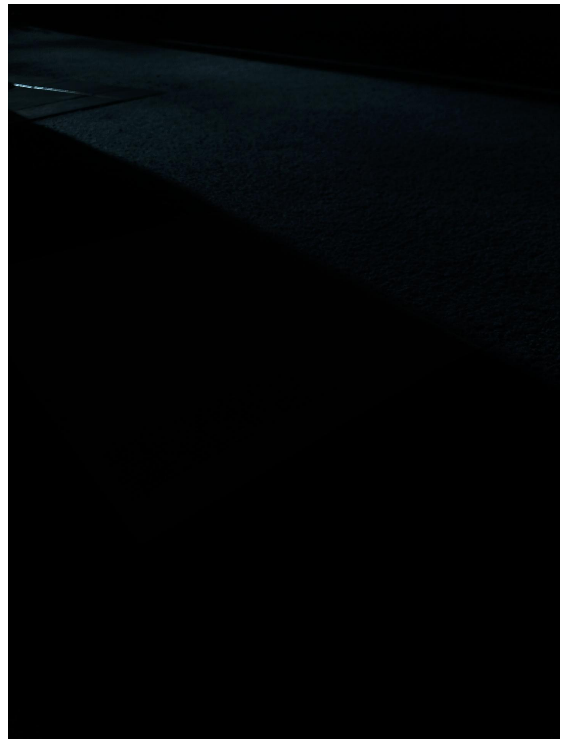
Linearized image at T = 1/2000 s



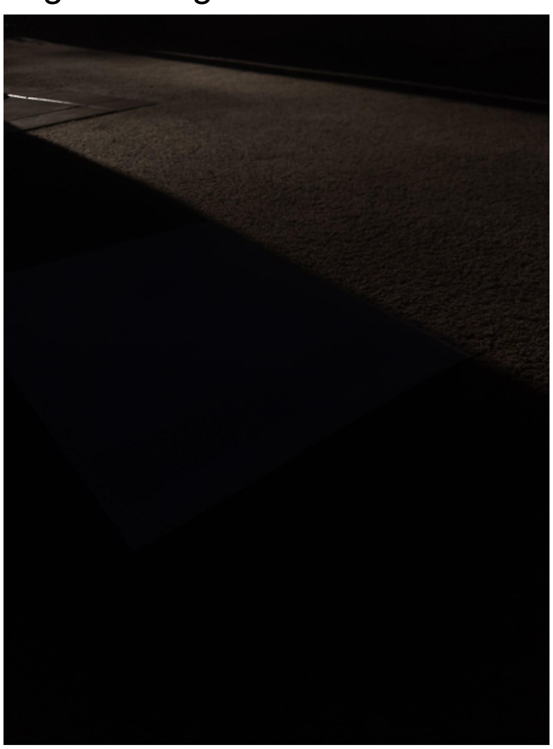
Original image at T = 1/2500 s



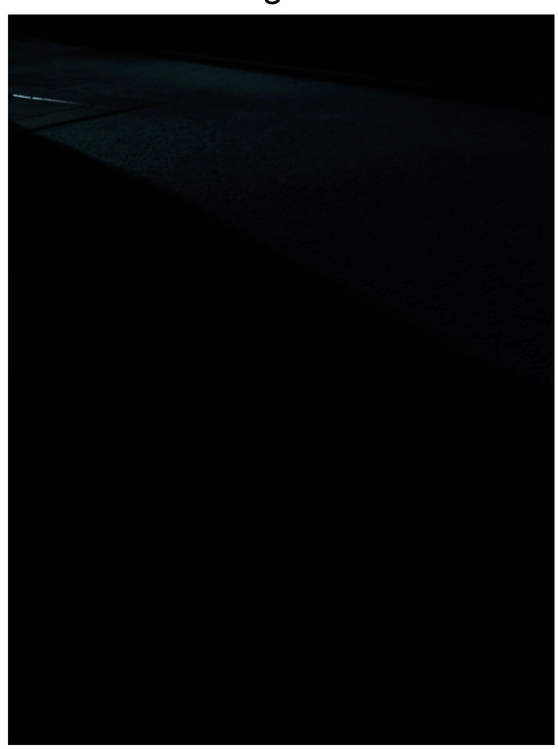
Linearized image at T = 1/2500 s



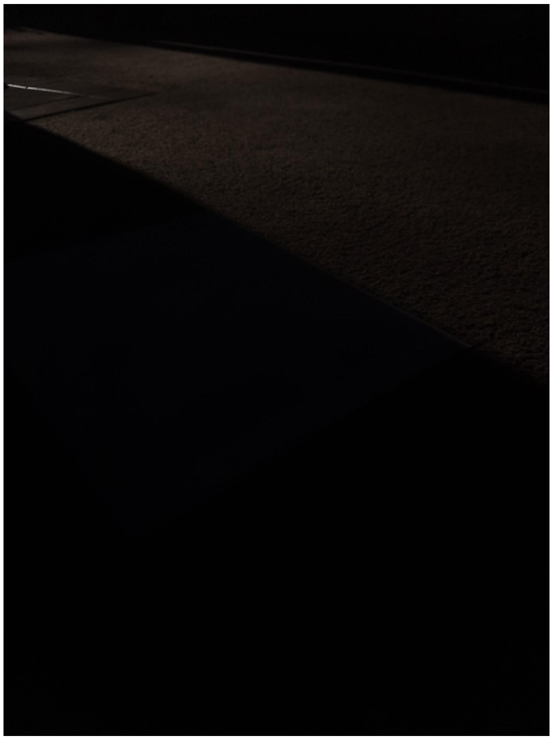
Original image at T = 1/3200 s



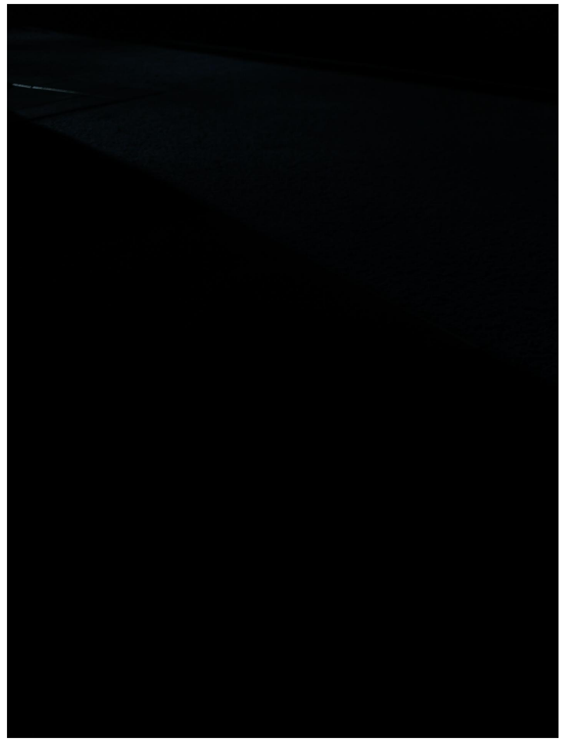
Linearized image at T = 1/3200 s



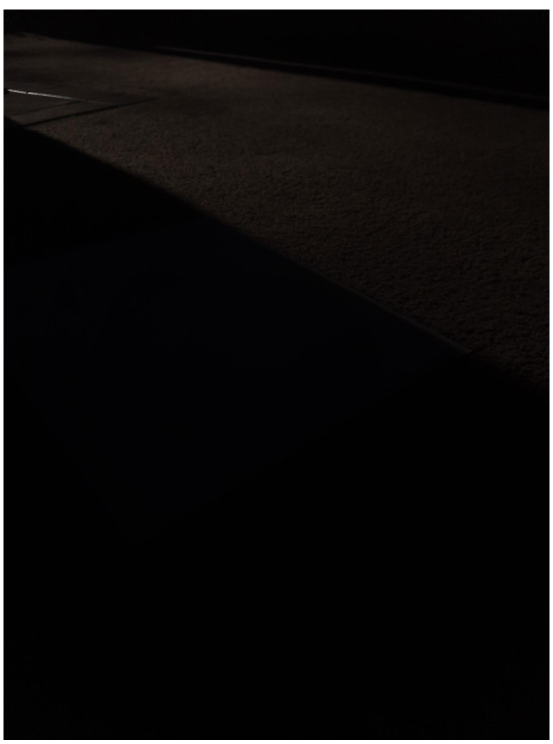
Original image at T = 1/5000 s



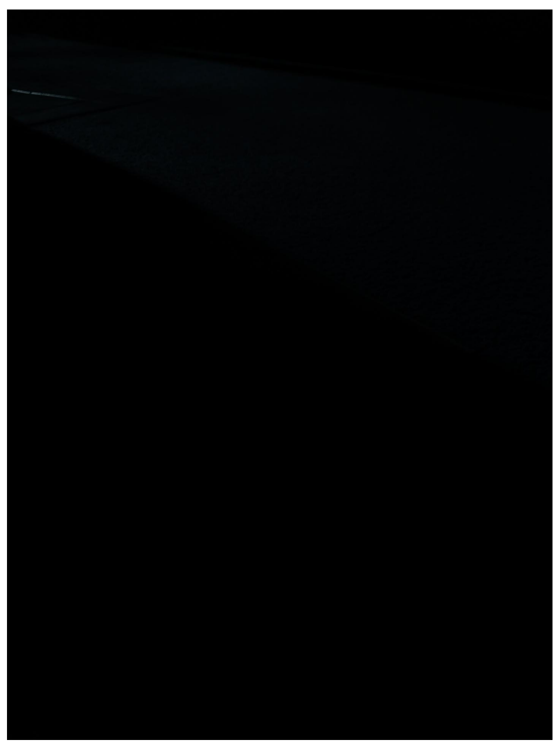
Linearized image at T = 1/5000 s



Original image at T = 1/6400 s

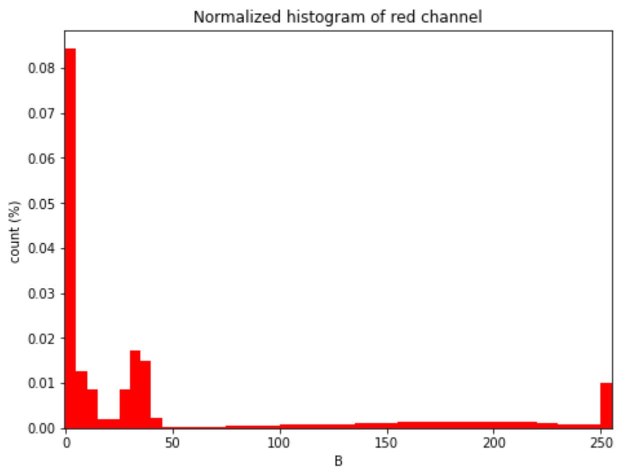


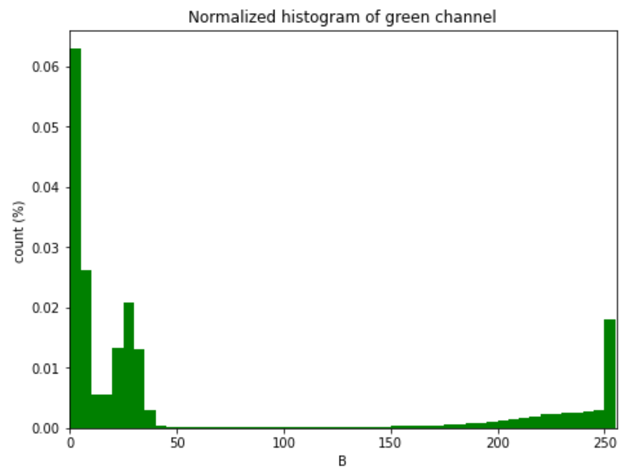
Linearized image at T = 1/6400 s

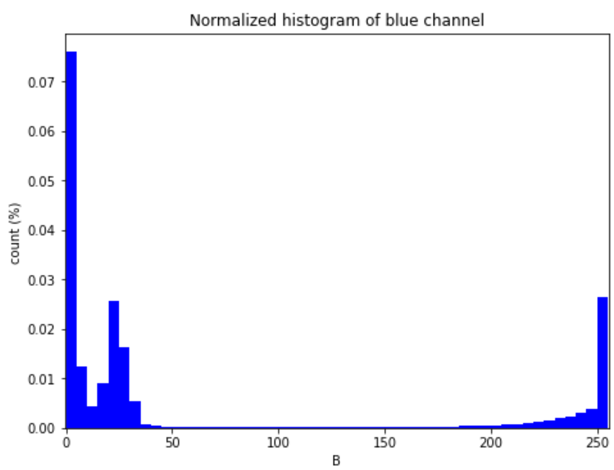


Below are the normalized histogram plots for the linearized image at $\bar{T}$ = 1/80s selected from the bunch of photos that we clicked:

The number of bins for the histogram is 255/5 = 51.

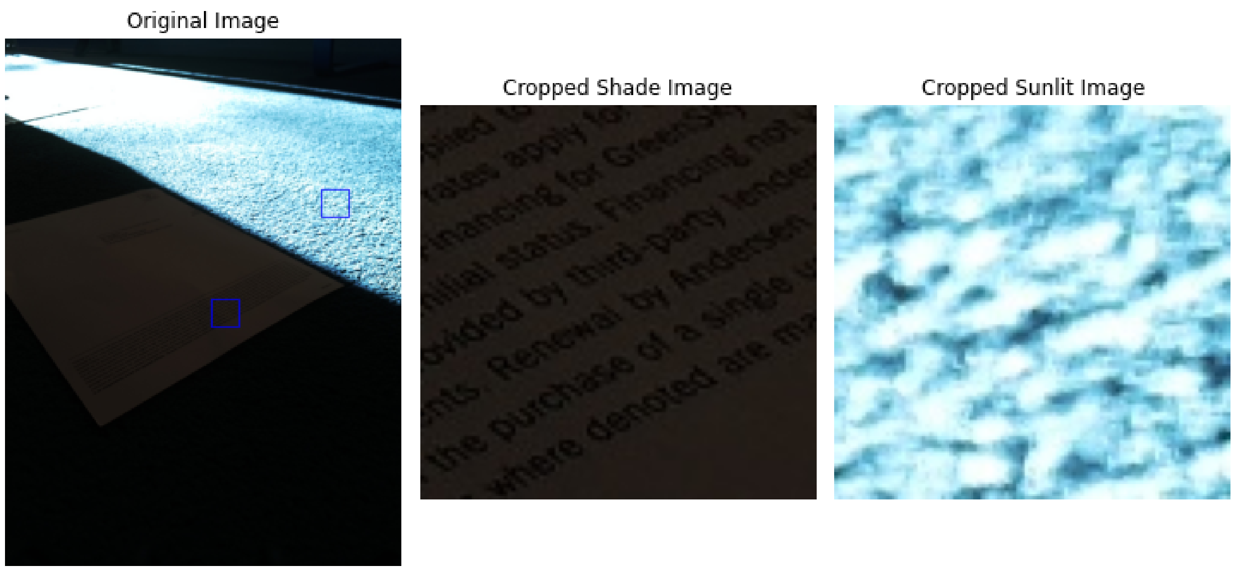






PART 3 - FIND THE CONTRAST VALUE

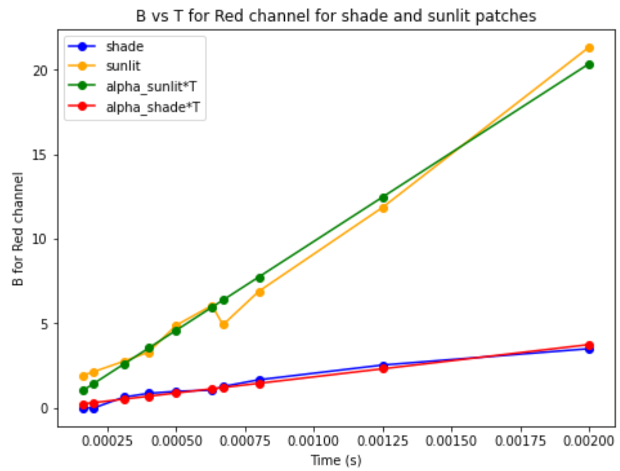
In this step, we select two 100x100 patches on the linearized image at $\bar{T}$ = 1/80s, one in the shaded area and one in the sunlit area. The patches selected are shown below in the image:

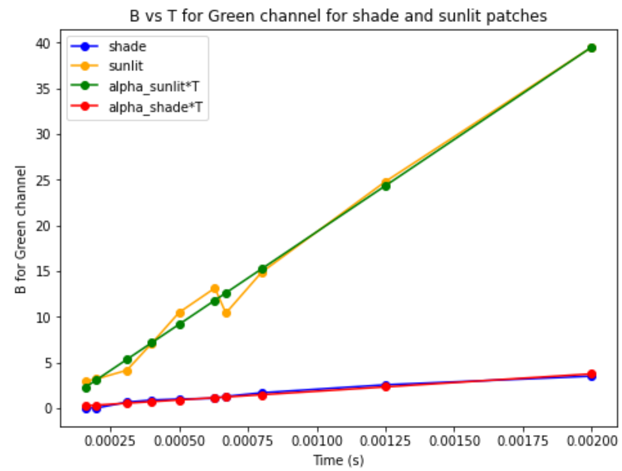


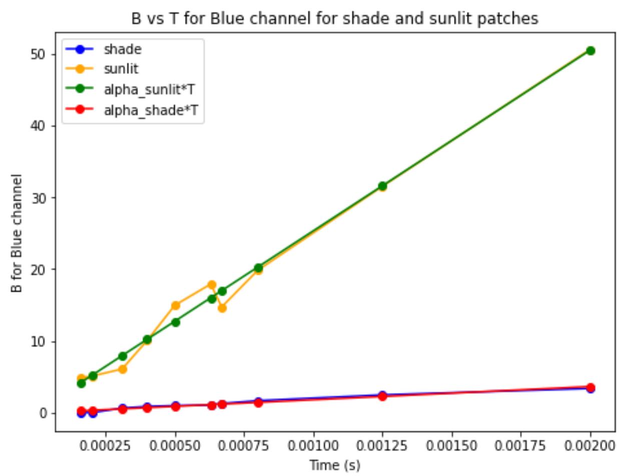
Our goal is to compute contrast between the two surface patches which will help us relight the shaded area. I find the average of the pixel values for each channel in the patch. Next, I compute linear least-squares regression of shaded and sunlit patches on all the images.

Once we perform the linear regression, we obtain $\alpha_{j,shade}$ and $\alpha_{j,sunlit}$ which helps us compute contrast for all the channels.

Below are the plots of $B_{j,sunlit}(T_i)$ and $B_{j,shade}(T_i)$ as a function of T for each color channel j, shown together with the regression lines $\alpha_{j,sunlit}T$ and $\alpha_{j,shade}T$:







The contrast values Kr, Kg, Kb obtained are (5.36, 10.49, 14.02) respectively.

PART 4 - RELIGHT

Our final step involves relighting the linearized image at $\bar{T}$ = 1/80s. I create a collage of the image with two components:

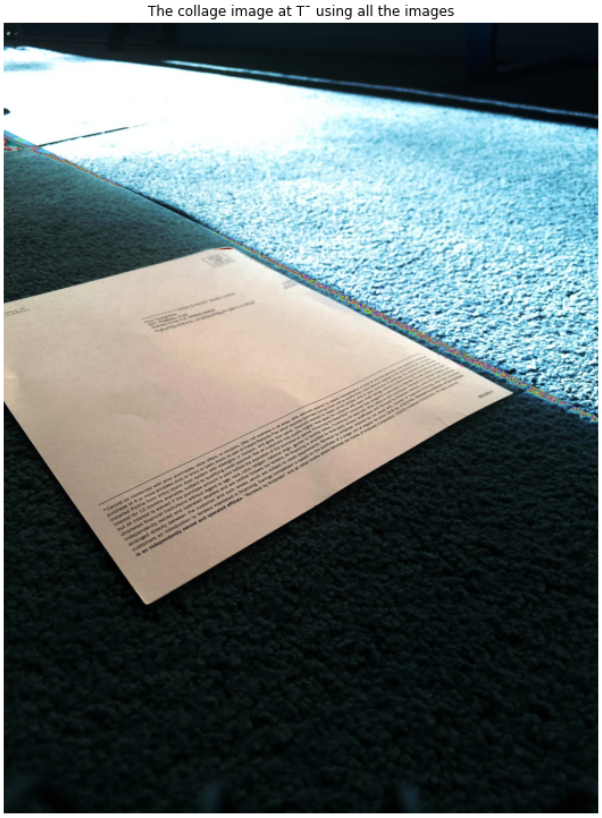
1. The background image at $\bar{T}$ = 1/80s and
2. The relit shadow area.

We have two approaches to relight an image, where the first one includes using all the images clicked at different exposure times to compute a weighted average of the pixel values of the image.

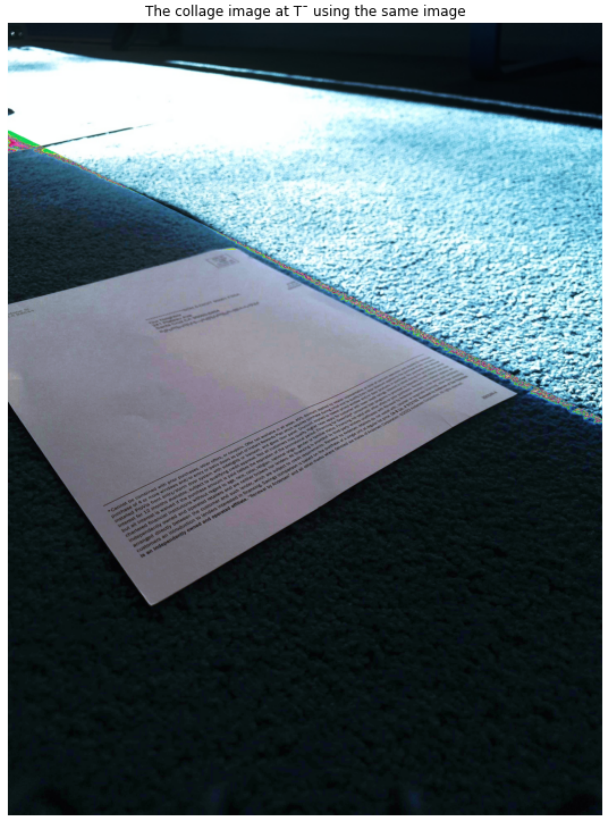
In the second approach, I can relit the shaded area of the image using the same image by multiplying all the pixel intensities by K_j for the respective channels.

Below is the relit image using all the images and using the same image:

The collage image at $\bar{T}$ using all the images



The collage image at $\bar{T}$ using the same image



Colab link for the project:
https://colab.research.google.com/drive/1I5jZkRqKktqAej3Z-mnRJCXGNHH1F3Nq?usp=sharing

Link to the Google Drive with Images, Colab, Project Report:
https://drive.google.com/drive/folders/1Qmbg1nfentzjUcdufzm6YyNcyD15isy_?usp=sharing