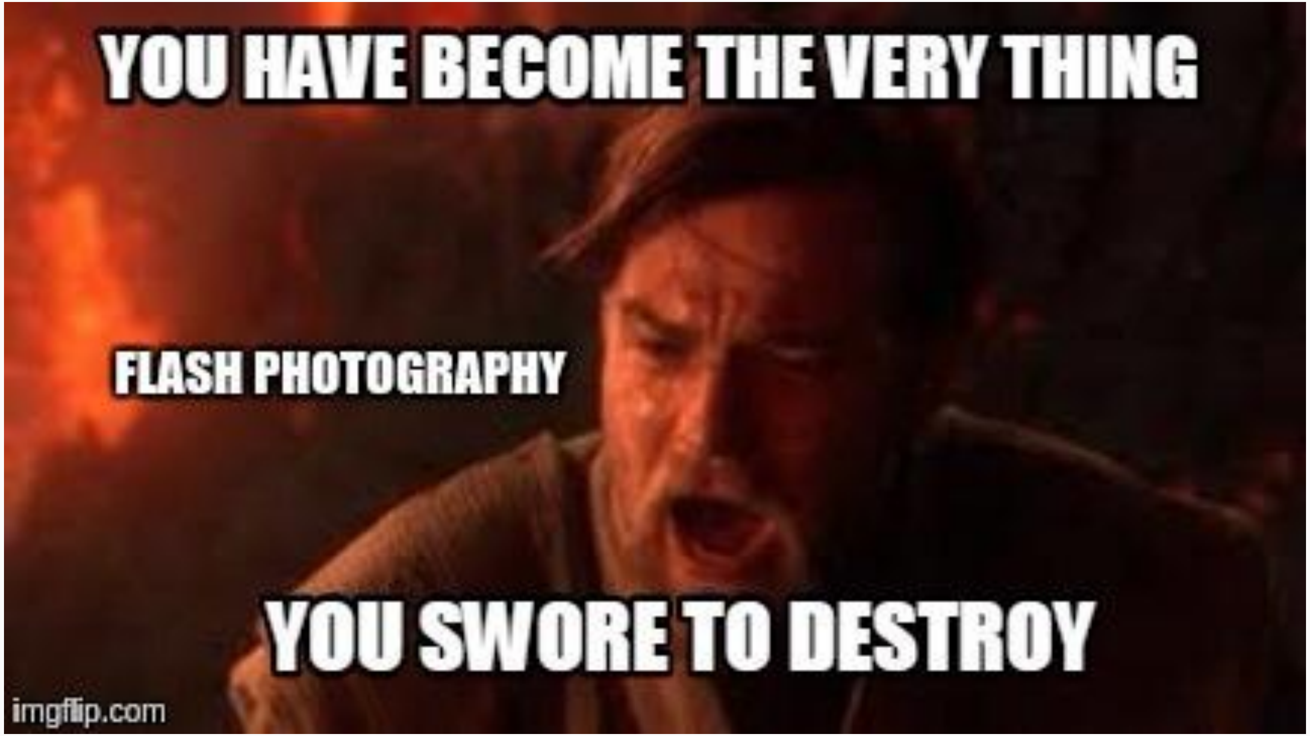
Digital Photography Using Flash and No Flash Images

DIPped In Chutney
1. Pranay Gupta, 20161088
2. Swapnil Pakhare, 20161199

MOTIVATION/PROBLEM STATEMENT

Flash Photography was invented to circumvent the problems occuring due to low light conditions. Flash images produce relatively sharp, noise-free images, brighter images have a greater signal to-noise ratio and can therefore have details that would be hidden in the noise in an image acquired under ambient illumination. Moreover, the flash can enhance surface detail by illuminating surfaces with a crisp point light source

However, the use of flash can also have a negative impact on the lighting characteristics of the environment. Objects near the camera are disproportionately brightened, the flash may introduce unwanted artifacts such as red eye, harsh shadows, and specularities, none of which are part of the natural scene.


YOU HAVE BECOME THE VERY THING
FLASH PHOTOGRAPHY
YOU SWORE TO DESTROY
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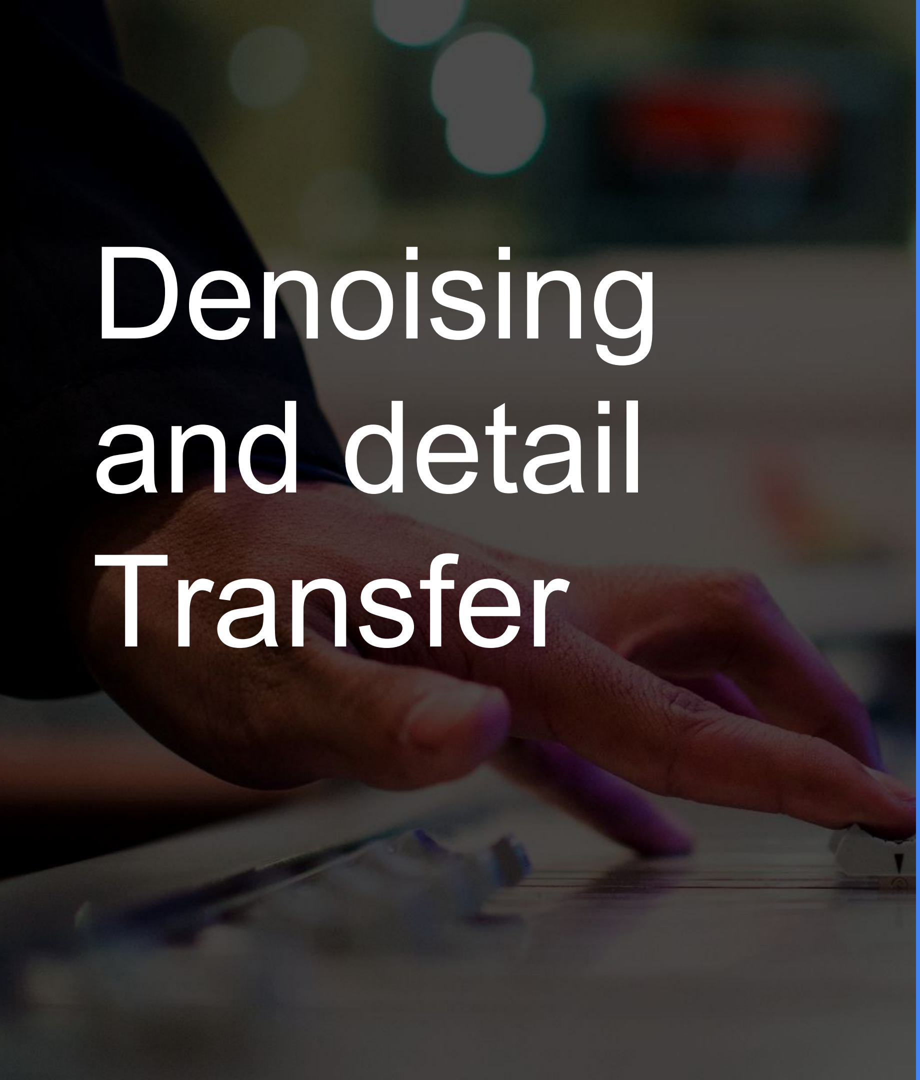
The solution

Digital photography makes it fast, easy, and economical to take a pair of images flash and ambient images and produce images with greater details. We present a variety of techniques that No-Flash Flash analyze and combine features from the images in such a flash/no flash pair. We perform the following features to remove the problems.

1. Denoising ambient images using shadow removal and flash details
2. White Balancing
3. Flash Adjustment
4. Red Eye Removal

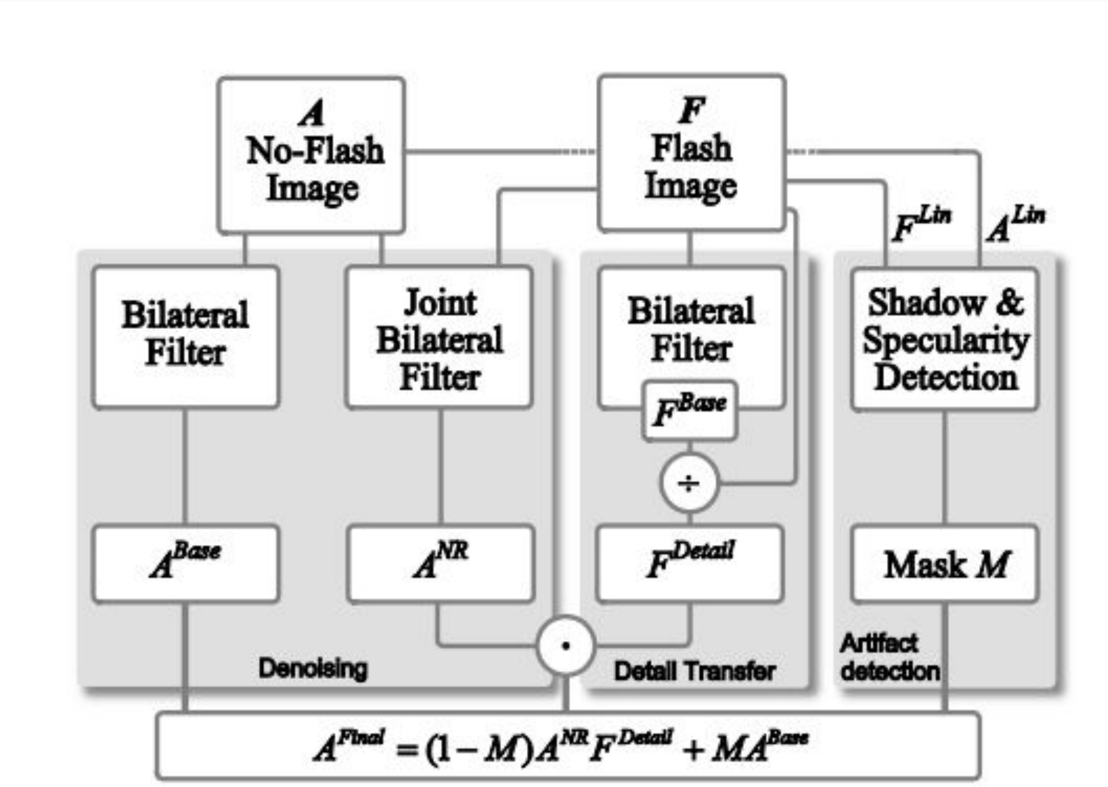


Denoising and detail Transfer

The flash image contains a much better estimate of the true high-frequency information than the ambient image. Based on this observation, we modify the basic bilateral filter to compute the range kernel using the flash image F. We call this technique the joint bilateral filter.

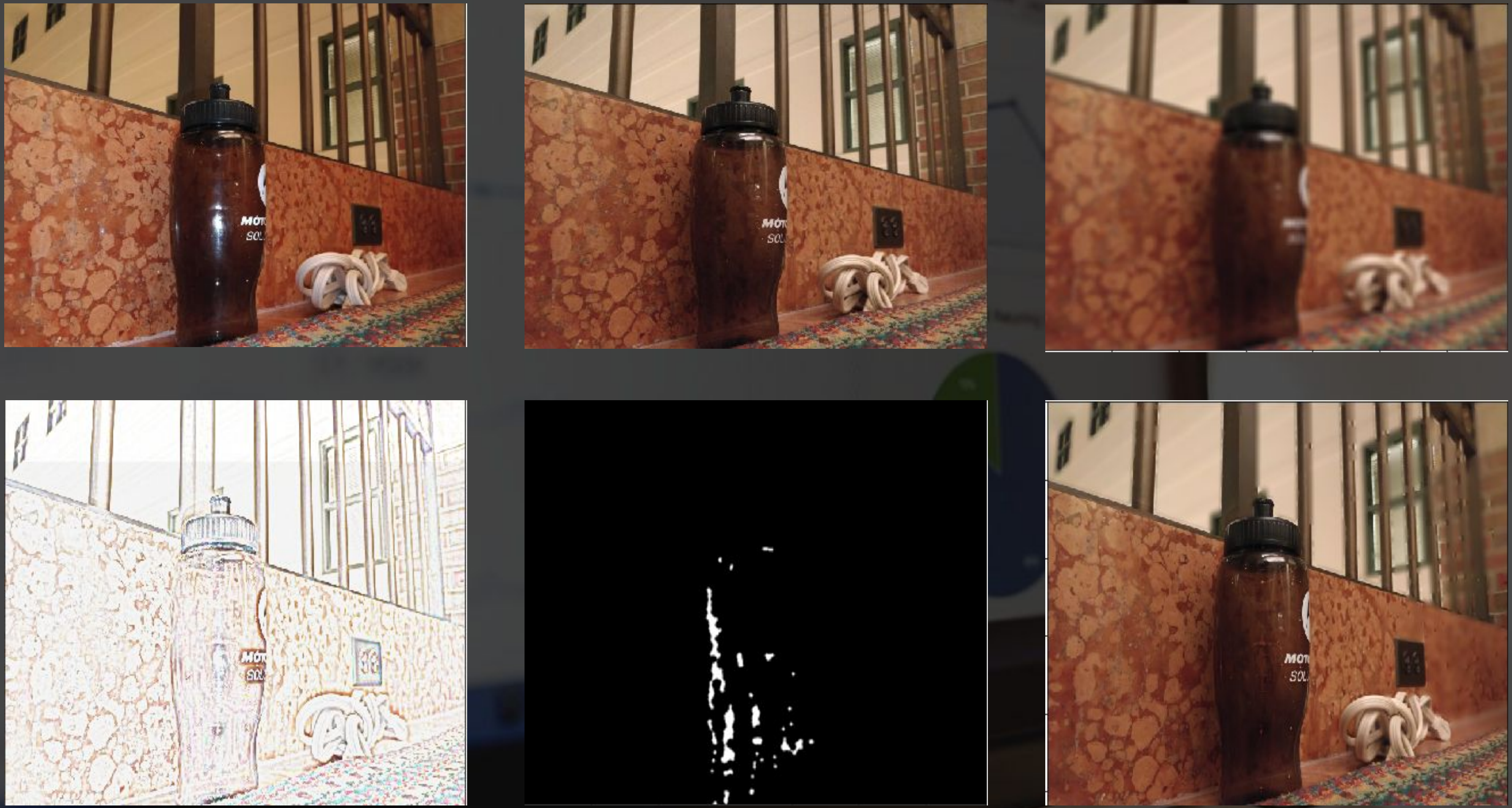
Now for the flash image to work properly we need the flash image to be a descriptor of the ambient image. So it will not perform proper blurring in presence of flash shadows and other artifacts missing in the ambient image. We solve this problem by first detecting flash shadows and specular regions and then falling back to basic bilateral filtering within these regions

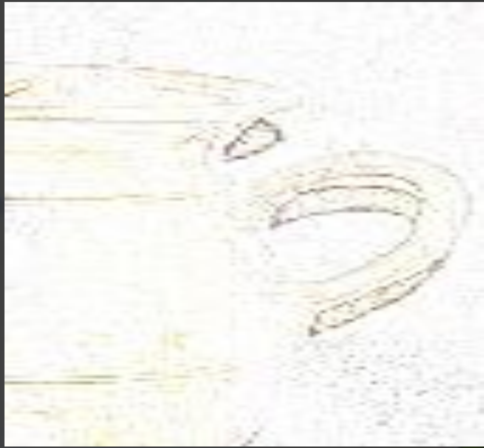
The filter reduces the noise but it cannot add details that are present in the flash image. So we calculate the detail layer and add it to the ambient image to produce the final sharp image.



$$M^{Shad} = \begin{cases} 1 \text{ when } F^{Lin} - A^{Lin} \le \tau_{Shad} \\ 0 \text{ otherwise.} \end{cases}$$

Ambient Image





White Balancing

First we perform Histogram equalization per channel for both inputs. Then we calculate the surface albedo per channel which is proportional to the illumination difference between each flash and no flash image.

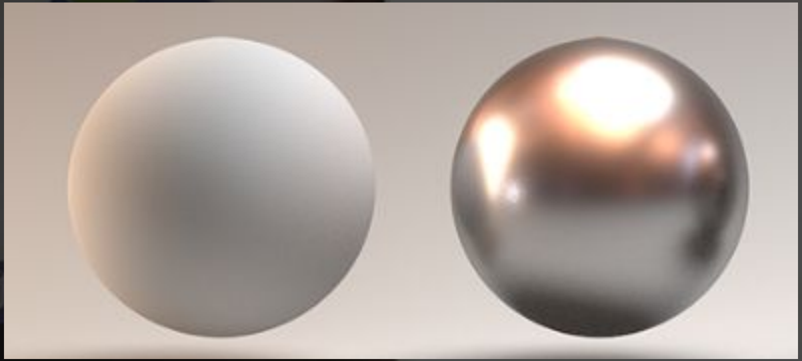
We then calculate ambient color(Cp) at each point by dividing the ambient image intensity and the surface albedo at that point. Our goal is to analyze Cp at all image pixels to infer the ambient illumination color c.

To make this inference more robust, we discard pixels for which the estimate has low confidence. Specifically, we ignore pixels for which either (ambient image intensity) $Ap < \tau 1$ or the luminance of Δp(Scaled Albedo) $< \tau 2$ in any channel, since these small values make the ratio less reliable. We set both $\tau 1$ and $\tau 2$ to about 2% of the range of color values.

We compute the ambient color estimate c for the scene as the mean of Cp for the non-discarded pixels.we white-balance the image by scaling the color channels as: $WB = Ap *(1/Cp)$

Assumptions

We consider the flash to be a point source of light and this flash color is the reference white and so the flash illumination of the image is actually the reflection of that flash light. Also we assume that either the object is completely diffuse or the diffuse color is same as the specular color, so that the difference between the ambient illumination and the flash illumination leads to the flash illumination alone. A



Ambient Image







Continuous Flash Adjustment

When taking a flash image, the intensity of the flash can sometimes be too bright, saturating a nearby object, or it can be too dim, leaving mid-distance objects under-exposed.

The most effective correction scheme is to convert the original flash/no-flash pair into YCbCr space and then linearly interpolate them using

$$FAdjusted = (1 - \alpha)A + (\alpha)F$$

To provide more user control, we allow extrapolation by letting the parameter α go outside the normal [0,1] range


alpha = -0.5
alpha = 0
alpha = 0.25
alpha = 0.5
alpha = 1
alpha = 1.5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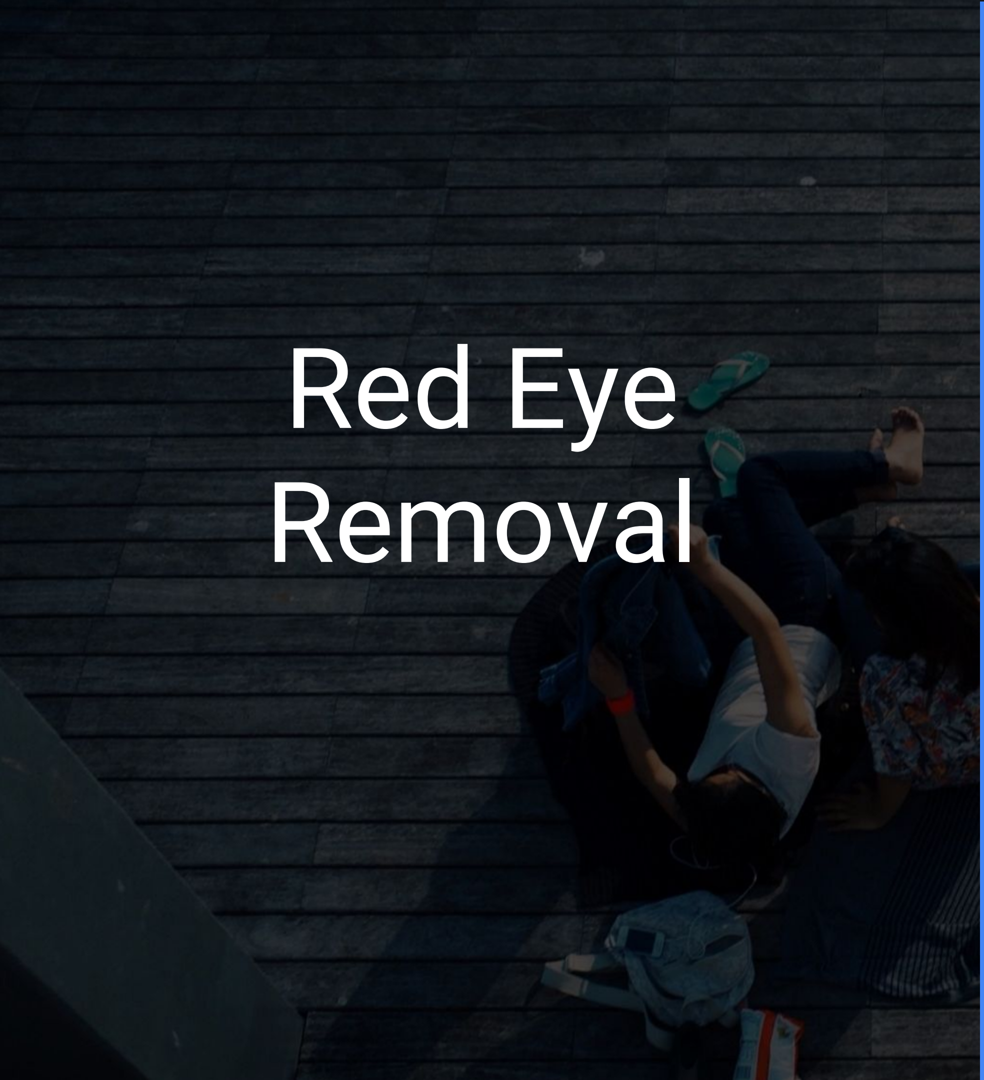
alpha = 0
alpha = 0.25
alpha = 0.5
alpha = 1
alpha = 1.5



Red Eye Removal

We convert the image pair into YCbCr space to decorrelate luminance from chrominance and compute a relative redness measure as follows

$$R = FCr - ACr$$

We then initially segment the image into regions where

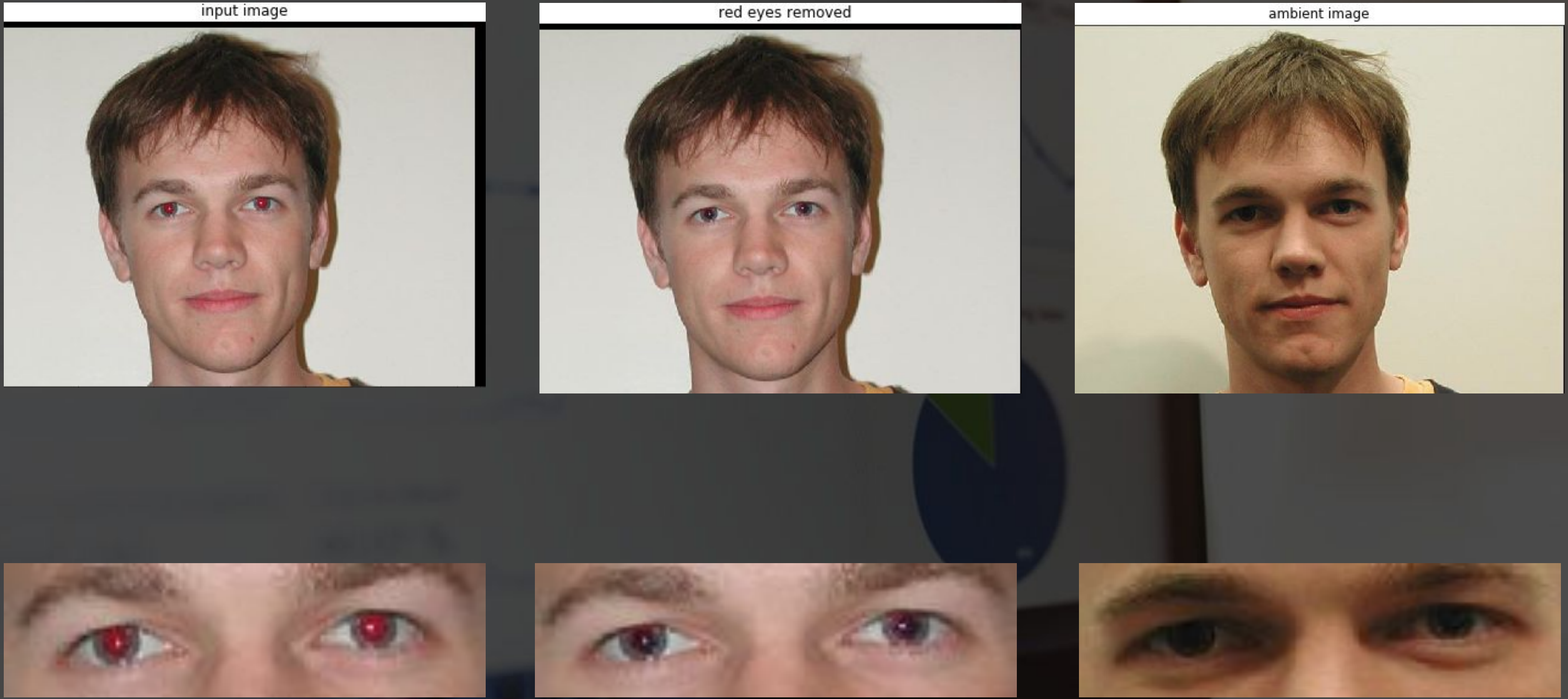
$$R > \tau Eye$$

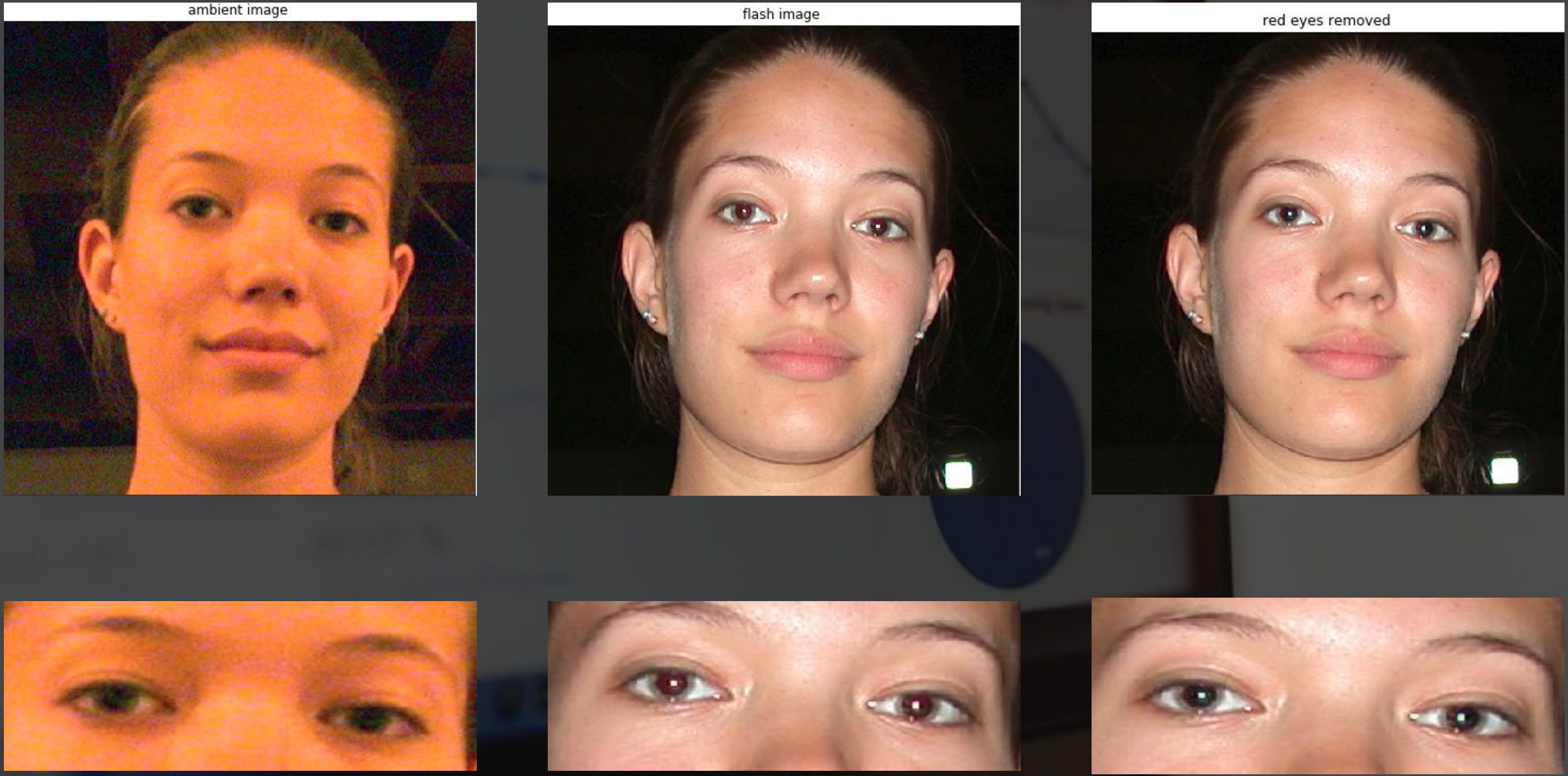
The segmented regions also tend to include a few locations that are highly saturated in the Cr channel of the flash image but are relatively dark in the Y channel of the ambient image. Thus we look for seed pixels where

$$R > \max[0.6,\ \mu R + 3\sigma R] \text{ and } AY < \tau Dark$$

We use these seed pixels to look up the corresponding regions in the segmentation and then apply geometric constraints to ensure that the regions are roughly the same size and elliptical

We then set the color of each pixel in the mask to the gray value equivalent to 80% of its luminance value


input image
red eyes removed
ambient image


ambient image
flash image
red eyes removed

Thank You!