Flash no Flash

(image denoising and enhancing)

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Link to all result images:-
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Abstract

Images that are taken in low lighting generally contain high noise. While those taken with help of flash remove the essence of the image due to the excessive lighting. Our project aims to remove the noise and enhance the edges in the ambient image while preserving the the originality of the image.

Goals

1. Remove noise,add high frequency components(edges) to the ambient images.
2. White balance the images

Image denoising

The Joint Bilateral filter

The ambient image contains lot of noise which can be removed by using the flashed image. The basic idea is that the edges(high frequency) are clear and more informative in the flash image. Thus, we use bilateral filter to smooth the image to remove noise in the ambient image while preserving edges from the flash image. The equation is:

$$A_p^{NR} = \frac{1}{k(p)} \sum_{p' \in \Omega} g_d(p' - p)\, g_r(F_p - F_{p'})\, A_{p'} ,$$

Flash to ambient detail Transfer

The edges are preserved with the bilateral filter but there may will be details present in the flashed in flash image which will not be present in the ambient image due to low lighting . Thus the flash image that contains better information about the texture is used to transfer detail to the ambient image.

$$F^{Detail} = \frac{F + \varepsilon}{F^{Base} + \varepsilon} ,$$

Detecting Flash Shadows and specularities

In the flash image there may be shadows of object and other specularities due to which there may be a formation of few boundaries and regious which suffer from noise and are not present in the ambient image.Now to avoid the use of this information we create a mask.
To create the mask we take the Difference of the Ambient and flash images and put a threshold so that only the regions which are present in the ambient image are masked out.

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

We use this mask along with the noise reduced image to remove the specularities and finally output the result.

$$A^{NR'} = (1 - M)A^{NR} + M\,A^{Base}.$$

To this we apply the Detail transfer to get the final image. The equation is:

$$A^{Final} = (1 - M)A^{NR}F^{Detail} + M\,A^{Base}.$$

Results of the above:-

*These are very large images to view the full image please open the link provided at the start of the report

Input 1:-

Flash Image

Ambient Image

Output 1:-

A_{Base}

A_{NR}

F_{base}

$F_{Details}$

Mask

Final result

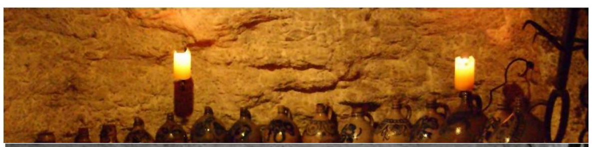
Input 2:-

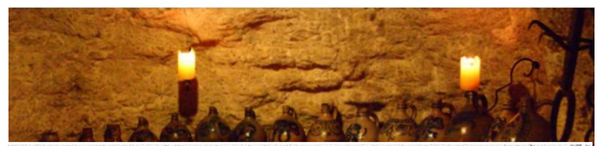
Ambient Image

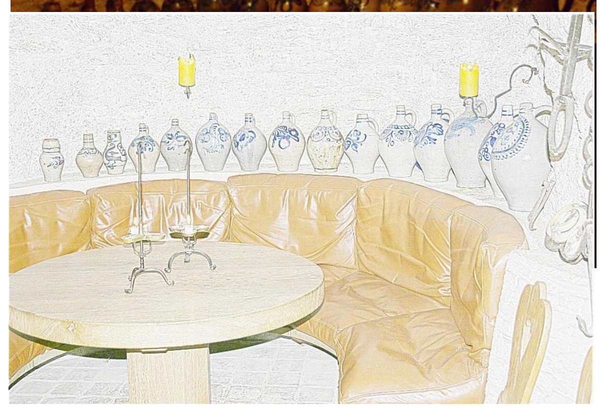
Flash Image

Output 2:-

A_{Base} A_{NR}







F_{base} $F_{Details}$

Mask

Final result

Input 3:-

Ambient Image

Flash Image

Output 3:-

A_{Base}

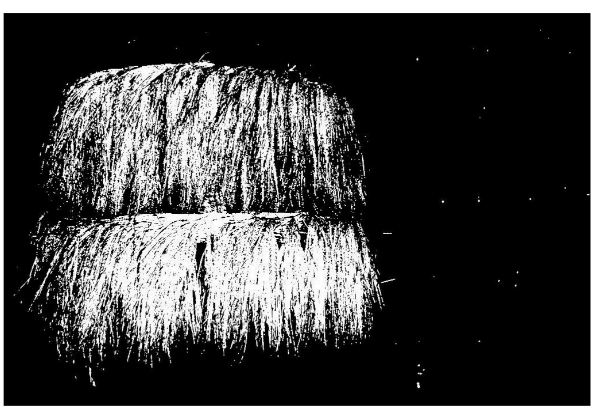
A_{NR}

F_{base}

$F_{Details}$

Mask

Final result



Input 4:-

Ambient Image

Flash Image

Output 4:-

A_{Base}

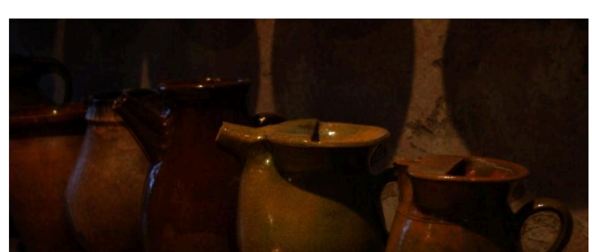
A_{NR}

F_{base}

$F_{Details}$

Mask

Final result



Input 5:-

Ambient Image

Flash Image

Output 5:-

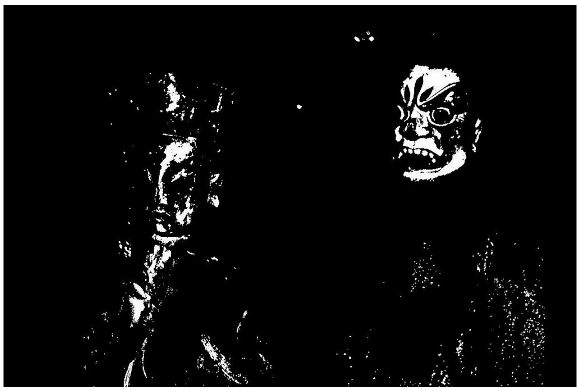
A_{Base}

A_{NR}

F_{base}

$F_{Details}$

Mask



Final result

White Balancing

In image processing, color balance is the global adjustment of the intensities of the colors(typically red,green and blue).An important goal of this adjustment is to render specific colors - particularly neutral colors - correctly. Although preserving the original ambient illumination is often desirable, sometimes we may want to see how the scene would appear under a more 'white' illuminance.

Thus the main aim would be to see how the image is under a more 'white' illuminance.

Procedure

We take the difference of the flash and ambient images to get the amount of illumination caused by the flash as difference image

Δ =F – A

The difference image corresponds to the illumination due to the flash only , since the surface pixel ***P*** has color A_p in the ambient image and the scaled albedo Δ_p (which is the difference image here), we can estimate the ambient illumination at the surgace with the ratio:

Cp = Ap/Δp

The Cp is computed per every channel. Our goal is to analyze *Cp* at all image pixels to infer the ambient illumination color *c*. We discard the pixels which have lesser intensity than the threshold to reduce or increase the amount of lighting in the image.

Finally, we compute the ambient color estimate *c* for the scene as the mean of *Cp* for the non-discarded pixels. (An alternative is to select *c* as the principal component of *C*, obtained as the eigenvector of $C^T C$ with the largest eigenvalue, and this gives a similar answer.) Having inferred the scene ambient color *c*, we white-balance the image by scaling the color channels as:

$$A_p^{WB} = \frac{1}{c} A_p$$

Results of the above:-

Input :-

Ambient Image

Flash Image

Output :-

*****The output 4 in the previous section is white balance as you can see

Red eye reduction:-

In flash photography one of the most common problem is the occurrence of Red-Eye. It is due to the light reflected by a well vascularised retina. Fully automated red-eye removal techniques usually assume a single image as input and rely on a variety of heuristic and machine-learning techniques to localize the red eyes. Once the pupil mask is detected, various other techniques are used to darken the pixels within the mask and make the image more natural.

The paper only discuss about the detection of red area in the image(includes regions which contain the pupil and other areas that appear red). Though we lack the knowledge to implement those techniques(machine learning etc) we came up with a few simple ones which produce a decent enough mask.

As the paper suggests we convert the given image to YCbCr colour space to decorrelate luminance from chrominance and compute a relative redness measure as follows:

$$R = F_{Cr} - A_{Cr}$$

We then segment the R into various regions with a threshold so that the resulting R gives only the regions which are redder in the flashed image than that of the ambient image which gives us all the regions which can potentially become red-eye.

But this may also include regions which are relatively dark in the 'Y' space of the image.

$$A_Y < \tau_{Dark}$$

Therefore to remove these regions we use another threshold in the Y space as follows:-

Finally after getting the possible areas for the red eye we used the following steps(ideal implementation of this part would require a lot of other techniques which are out of our scope):-

->We first check for the regions which have area similar to eye and have similar eccentricity of the eye.

-> after getting these regions we take the flash specularity mask mentioned previously and subtract that from the above as there may be multiple regions apart from eyes which may contain redness. As eyes do not give the shadow there are retained.

->now we blur this mask (gaussian) as the may be some pixels outside the eye-region even after the above step(used in some cases only) to get the final mask.

Now we get a mask with only highlight the red eye region.Therefore finally we do as follows:-

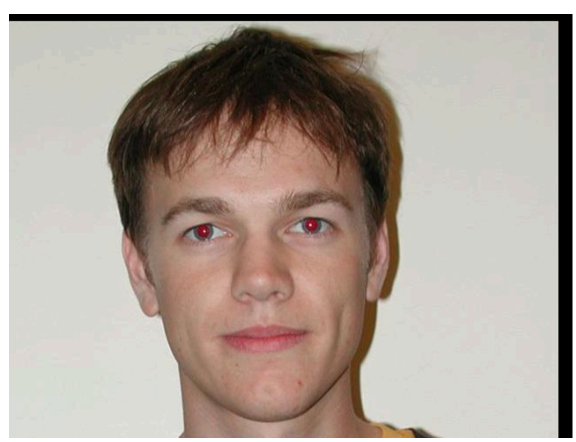
A.*finalmask + F.*(1-finalmask)

This give us a red eye reduced image. But details such as the lighting effect of the pupil(shine of the pupil) in the flashed image are not trasferred with this. This requires application of various other techniques which are out of our scope.

Input 1:-

Ambient Image

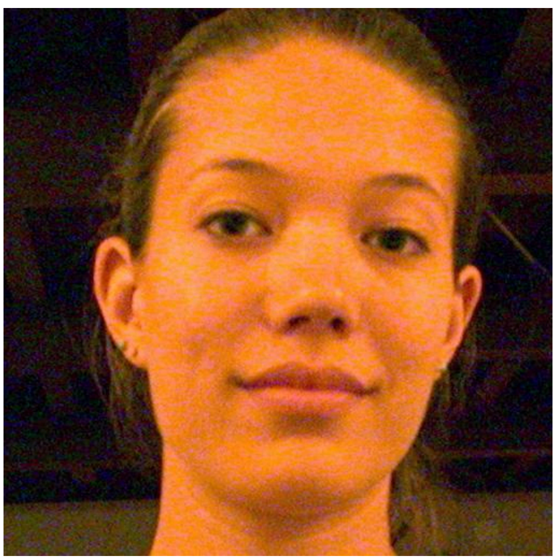
Flash Image



Output 1:-

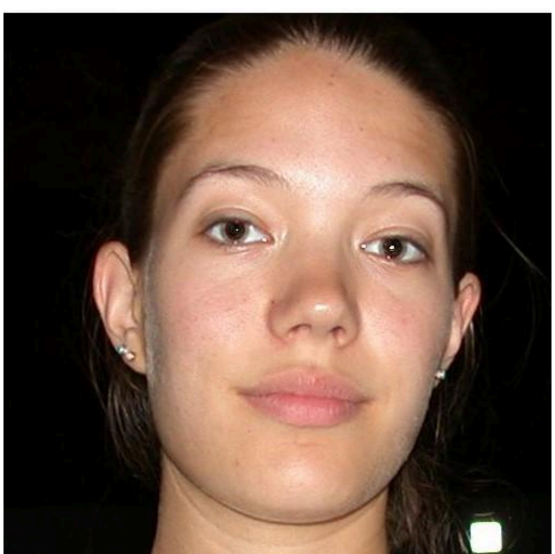
Input 2:-

Ambient Image



Flash Image

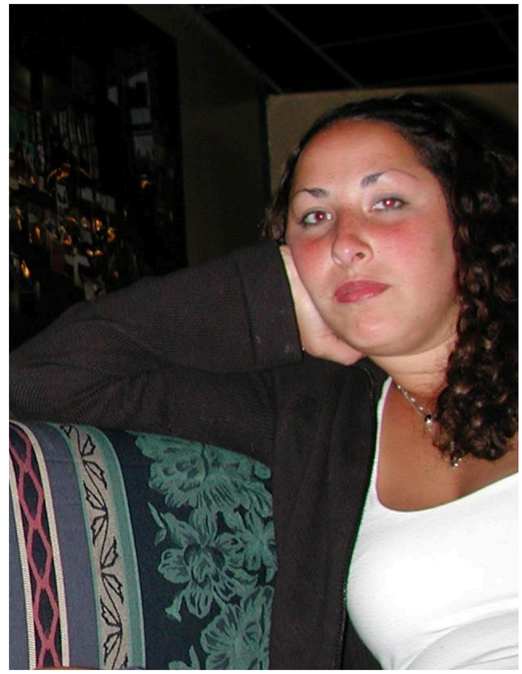
Output 2:-



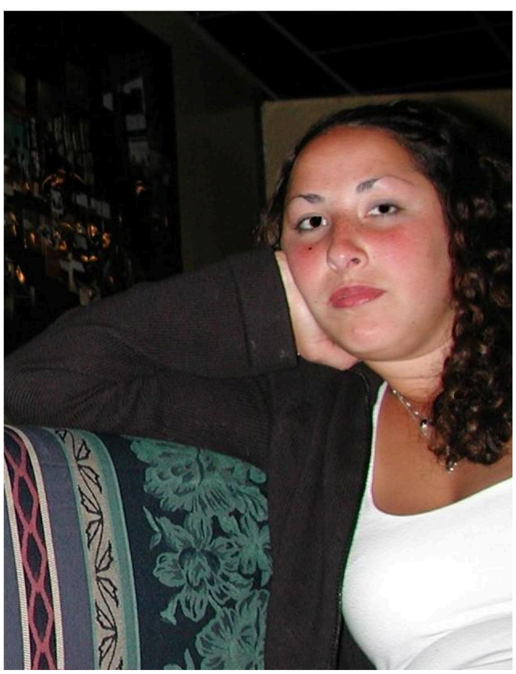
Input 3:-

Ambient Image

Flash Image



Output 3:-



Input 4:-

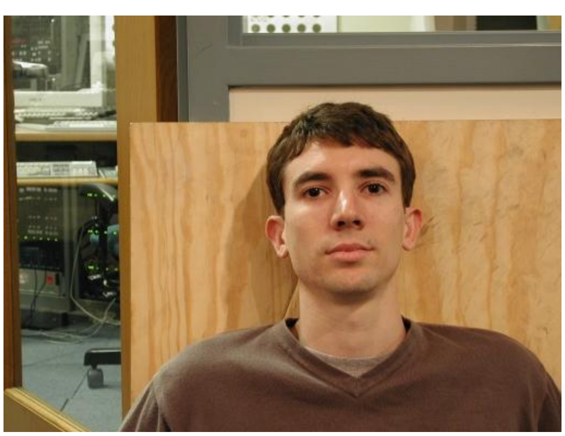
Ambient Image

Flash Image

Output 4:-

Input 5:-

Ambient Image



Flash Image

Output 5:-