Image Reflection Removal

Using Ghosting Cues

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Repository [Link]

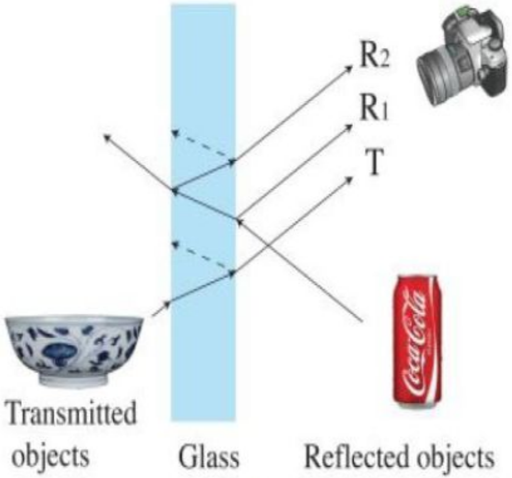
Paper : http://people.csail.mit.edu/yichangshih/mywebsite/reflection.pdf | CVPR 2015

Introduction

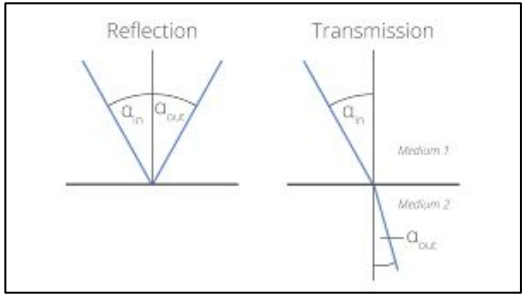
When taking a picture through a window pane, undesirable reflections of objects often cause a hindrance to the captured image.

One may try to use different techniques to minimize these reflections but this isn't always possible.

This raises the **need for post-processing** to remove reflection artifacts.



Challenge



Traditional imaging model formulation :

$$\boxed{I=T+R}$$

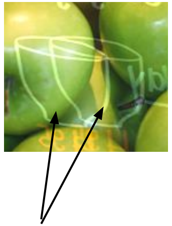
As both T and R are natural images and appear with the same statistical properties, separating them is an ill-posed problem.

Key Idea Used

Break the symmetry between transmission and reflection layers using the concept of ‘Ghosting cues’.

What’s Ghosting ?

It’s the appearance of a secondary reflected image on the captured image, like when window reflections often appear multiple times.



Double reflection - ghosting

Problem formulation

Images taken through glass windows often contain undesirable reflection artifacts.

In this project, the original image is considered to be composed of a reflection layer (undesirable) and a transmission layer (desirable).

$$\boxed{I = T + R \otimes k + n}$$

where I is Original Image

T is Transmission layer

R is Reflection layer

k is two-pulse kernel

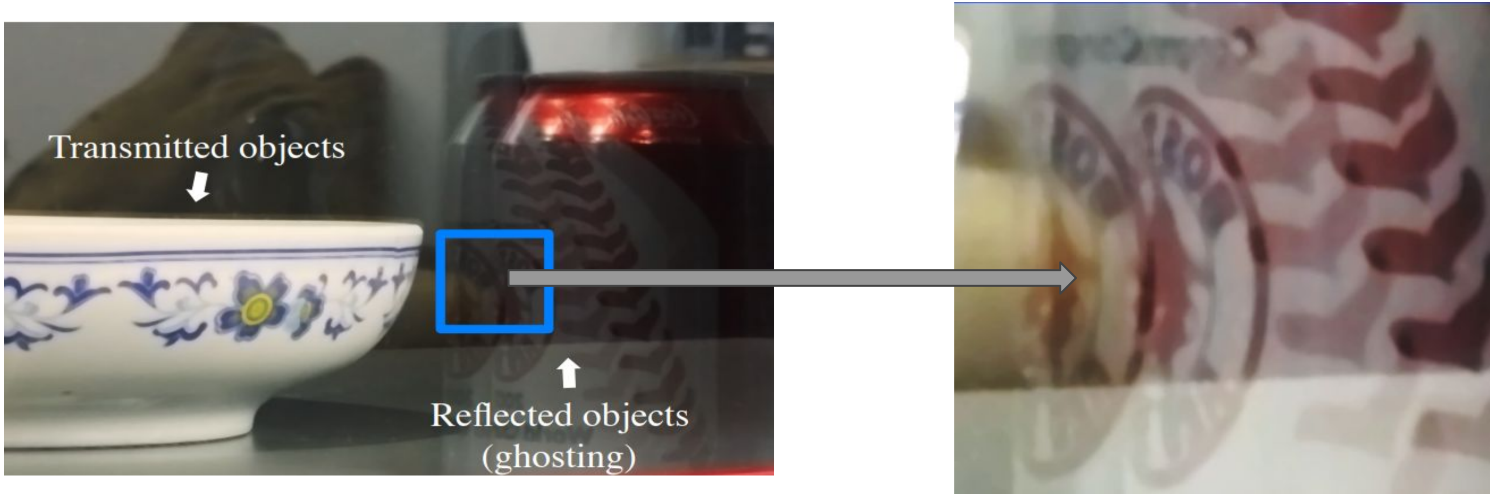
n is additive Gaussian noise

The original image is modeled as a mixture of these layers and the desirable image component is recovered after removing the undesired reflection layer.

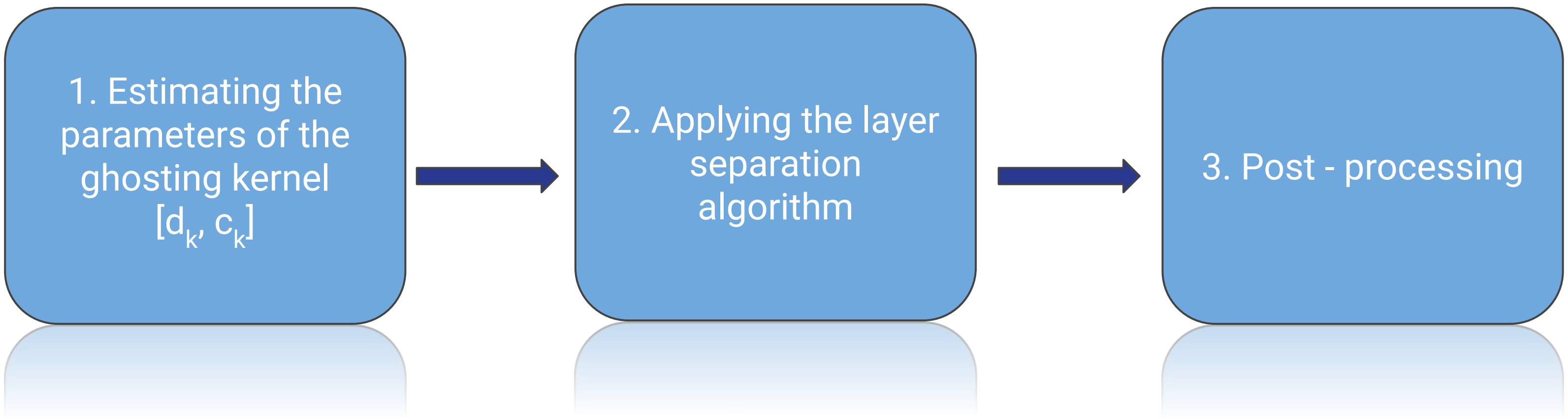
Heuristic applied

Ghosting cues exploit asymmetry between the layers which arise from **shifted double reflections** of the reflected scene off the glass surface.

In **double-pane windows**, each pane reflects shifted and attenuated versions of objects on the same side of the glass as the camera. For **single-pane windows**, ghosting cues arise from shifted reflections on the two surfaces of the glass pane.



Solution Overview



Modelling Ghosting Kernel

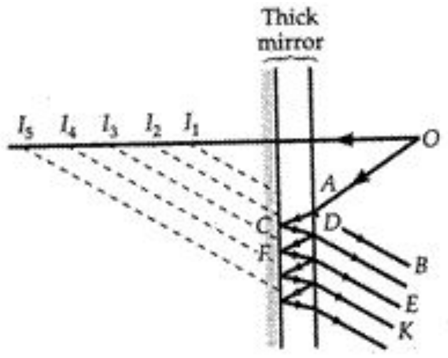
Using a two pulse kernel k :

$$I = T + R \otimes k$$

Ghosting kernel, k is parameterized by the spatial offset $\mathbf{d_k}$ and the attenuation factor $\mathbf{c_k}$.

Assumptions while modelling ghosting

- We model the kernel k as a two-pulse kernel, parameterized by the distance and the relative intensity between the primary and secondary reflections
- We ignored higher order reflections as they carry minimal energy
- In this case we have not considered ghosting in the transmitted layer

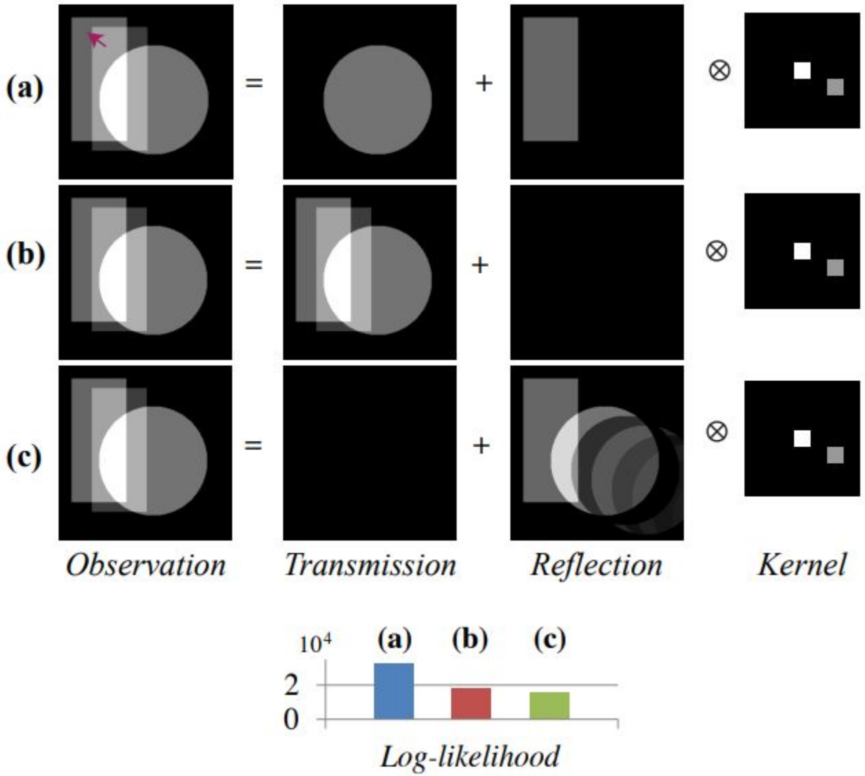


An example

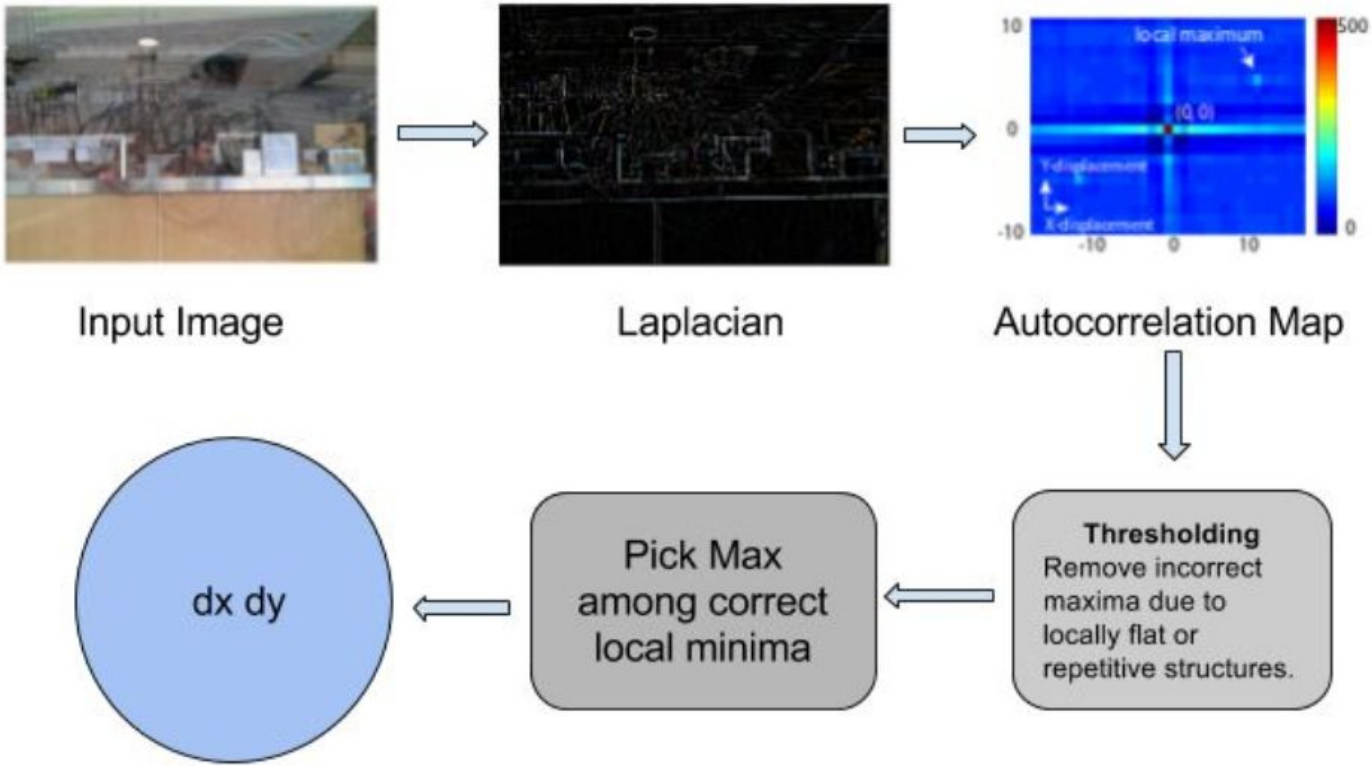
A synthetic example with a circle as the transmission layer and a rectangle as the reflection layer.

We compare the log likelihoods of the various possible decompositions under a GMM Model.

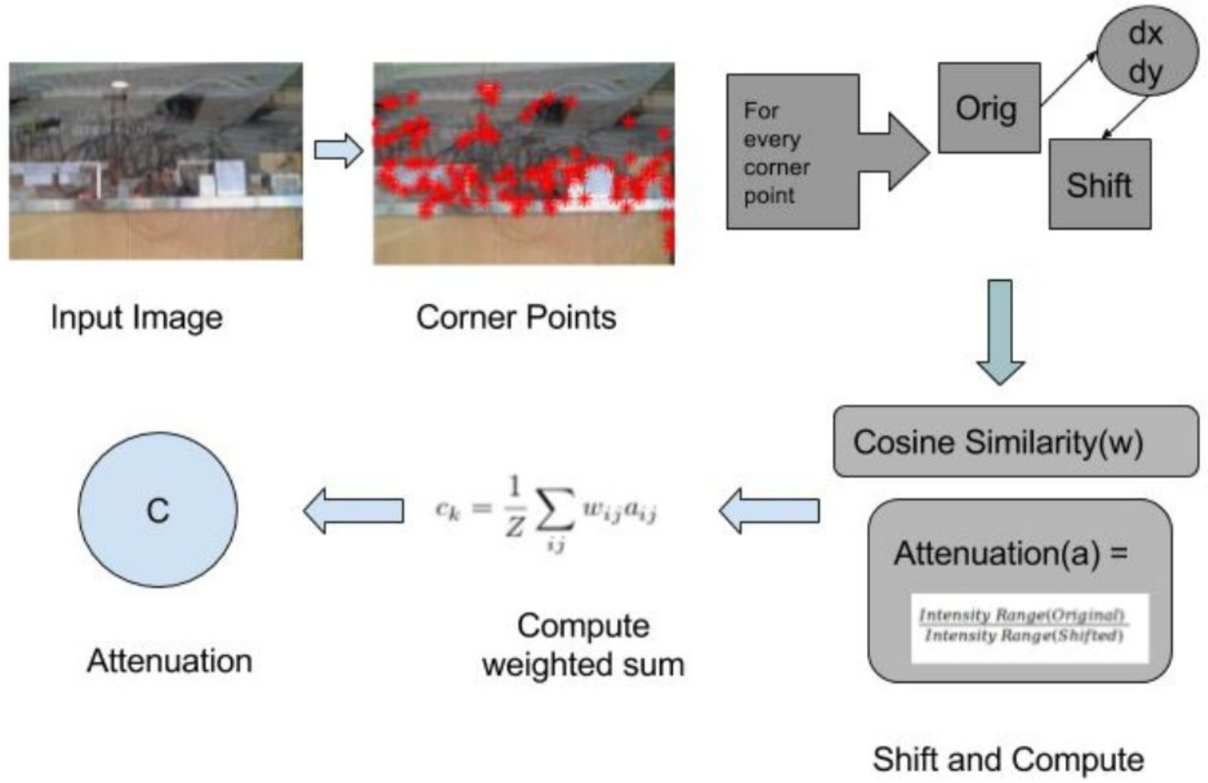
The log likelihood of the **a** is the highest, (implying it's most "natural") which is the ground truth.



Estimating Kernel Parameters (spatial offset)

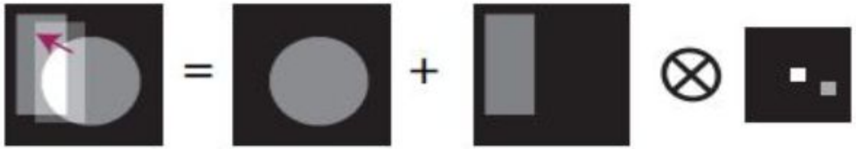


Estimating Kernel Parameters (atten factor)



Results

$$I = T + R \otimes k$$



```
>> simple(64,64,4,6,0.7)
Creating Image with dx= 4,dy= 6
>> deghost_img 'simple_input.png'
Size of image: 64 64 3
Estimating Ghosting kernel...Estimating spatial shift offset..
Estimating attenuation factor...
Done.dx: 2
dy: 8
c: 6.951574e-01
```

```
>> deghost_img 'images/test.png'
Size of image: 400 540 3
Estimating Ghosting kernel...Estimating spatial shift offset...
Estimating attenuation factor...
Done.dx: 32
dy: 2
c: 9.334746e-01
```