Image Reflection Removal

Using Ghosting Cues

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Repository [Link]

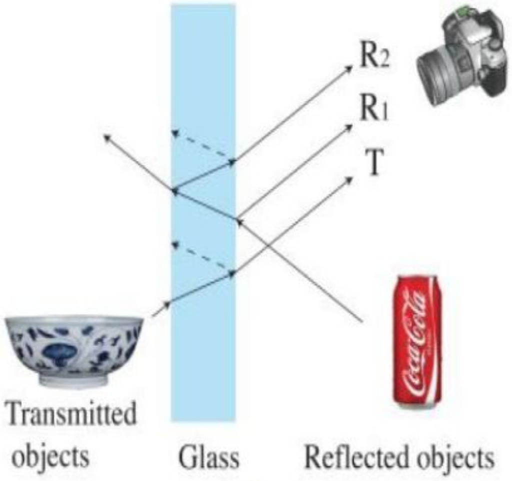
Paper : http://people.csail.mit.edu/yichangshih/mywebsite/reflection.pdf | CVPR 2015

Introduction

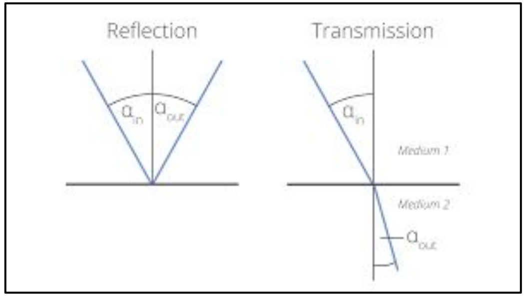
When taking a picture through a window pane, undesirable reflections of objects often cause a hindrance to the captured image.

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 :

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

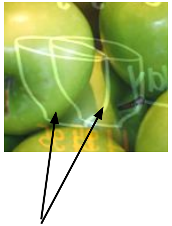
As both T and R are natural images and appear with the same statistical properties, separating them is an ill-posed problem.

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

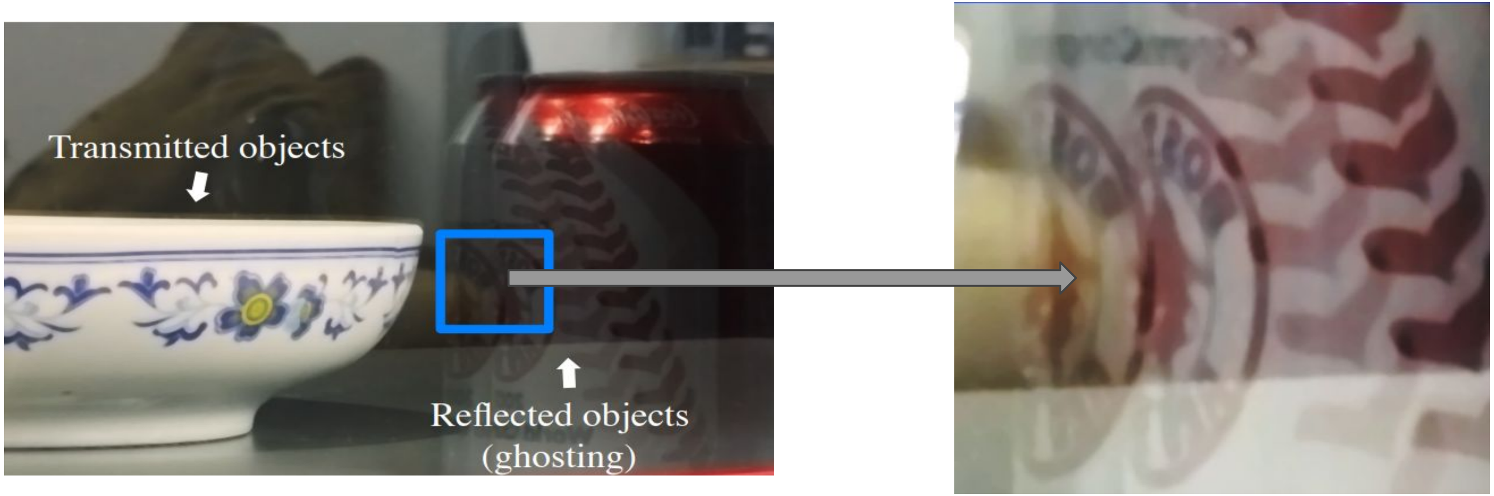
n is additive Gaussian noise

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

1. Estimating the parameters of the ghosting kernel $[d_k, c_k]$ → 2. Applying the layer separation algorithm → 3. Post - processing

Modelling Ghosting Kernel

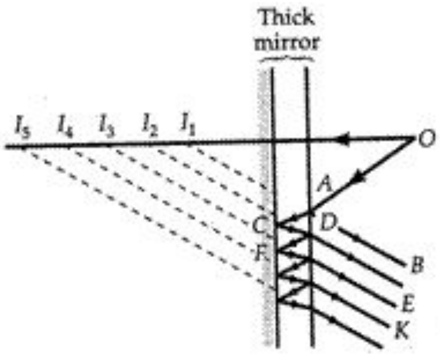
Using a two pulse kernel k :

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

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

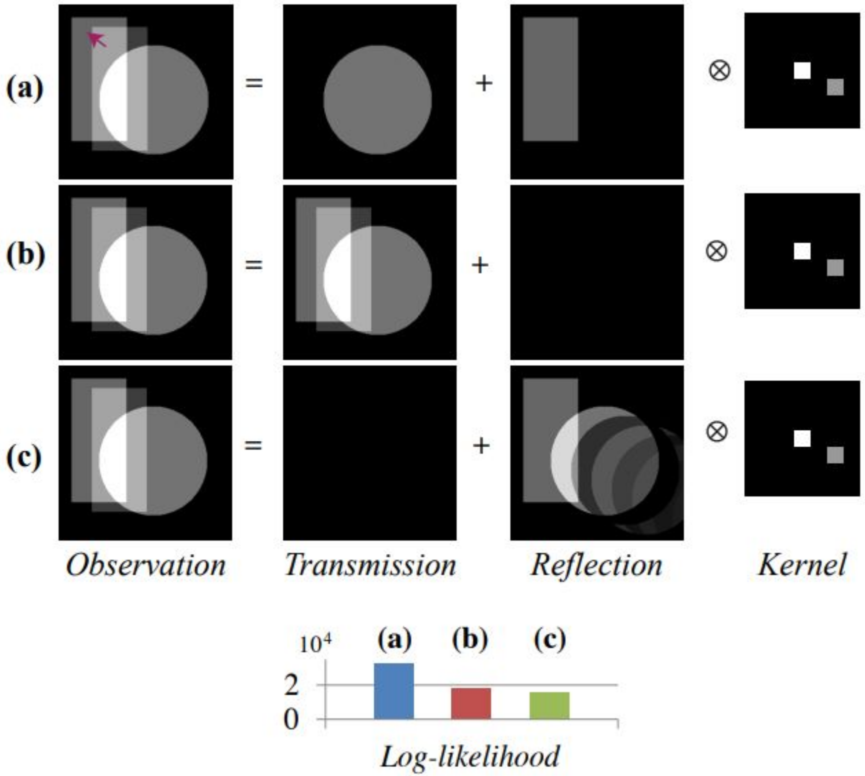


An example

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.

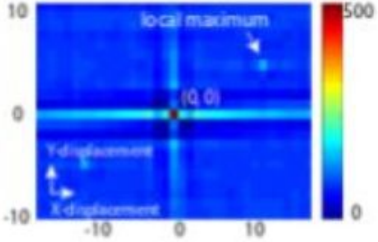
The log likelihood of the **a** is the highest, (implying it's most "natural") which is the ground truth.



Estimating Kernel Parameters (spatial offset)

Input Image

Laplacian



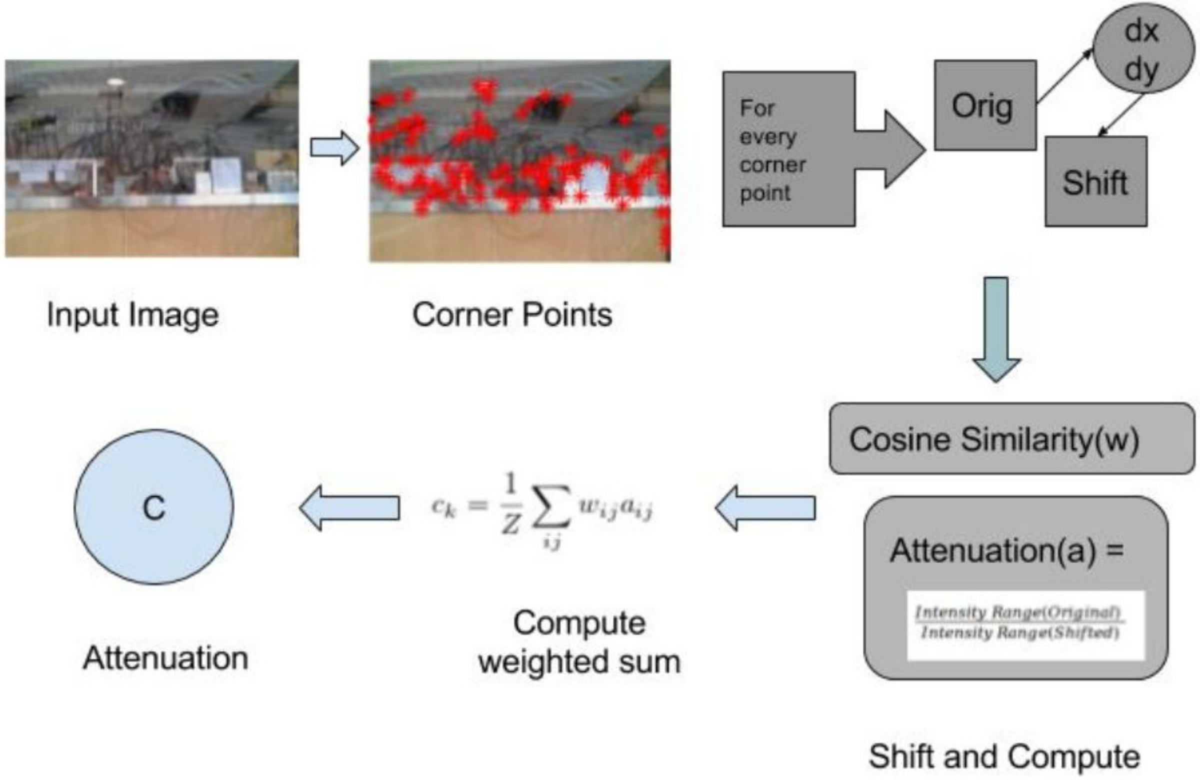
Autocorrelation Map

Thresholding
Remove incorrect maxima due to locally flat or repetitive structures.

Pick Max among correct local minima

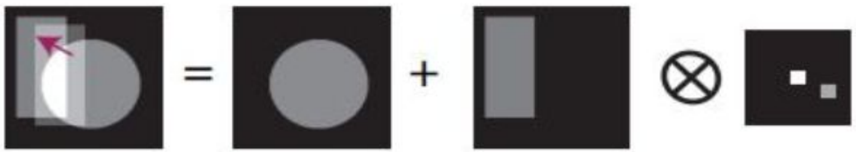
dx dy

Estimating Kernel Parameters (atten factor)



Results

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



```
>> simple(64,64,2,5,0.5);
Creating Image with dx= 2,dy= 5
>> deghost_img 'simple_input.png';
Size of image: 64 64 3
Estimating Ghosting kernel...Estimating spatial shift offset...
Testing:Estimating attenuation factor...
Done.dx: 2
dy: 7
c: 2.441340e-02
```

```
>> deghost_img './images/test.png';
Size of image: 400 540 3
Estimating Ghosting kernel...Estimating spatial shift offset...
Testing:Estimating attenuation factor...
Done.dx: 32
dy: 2
c: 7.226533e-01
```