Image Reflection Removal

Computer Vision Project Proposal

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Introduction

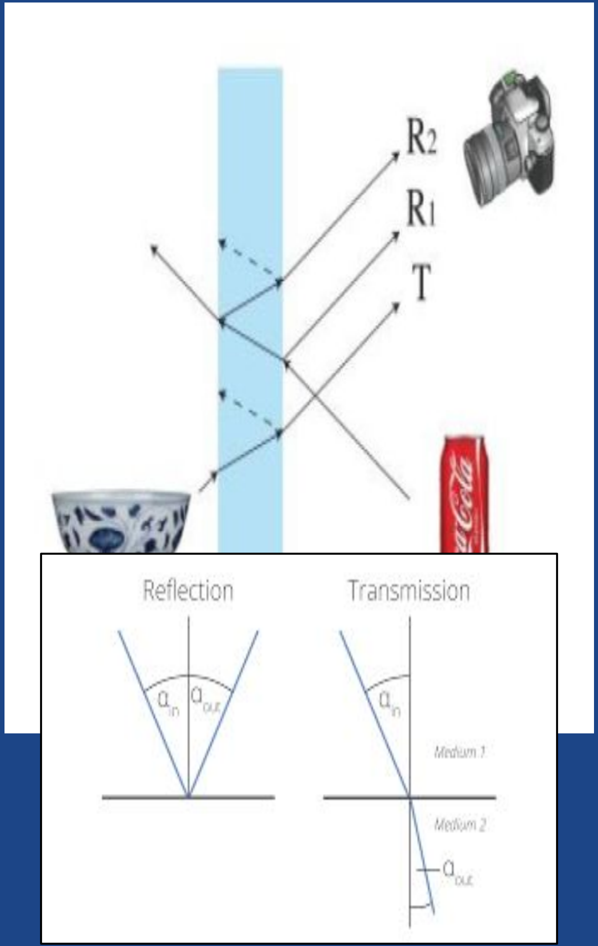
When taking a picture through a window pane, undesirable reflections of objects often cause a hindrance to the captured image.

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

Traditional imaging model formulation :

$$I=T+R$$

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

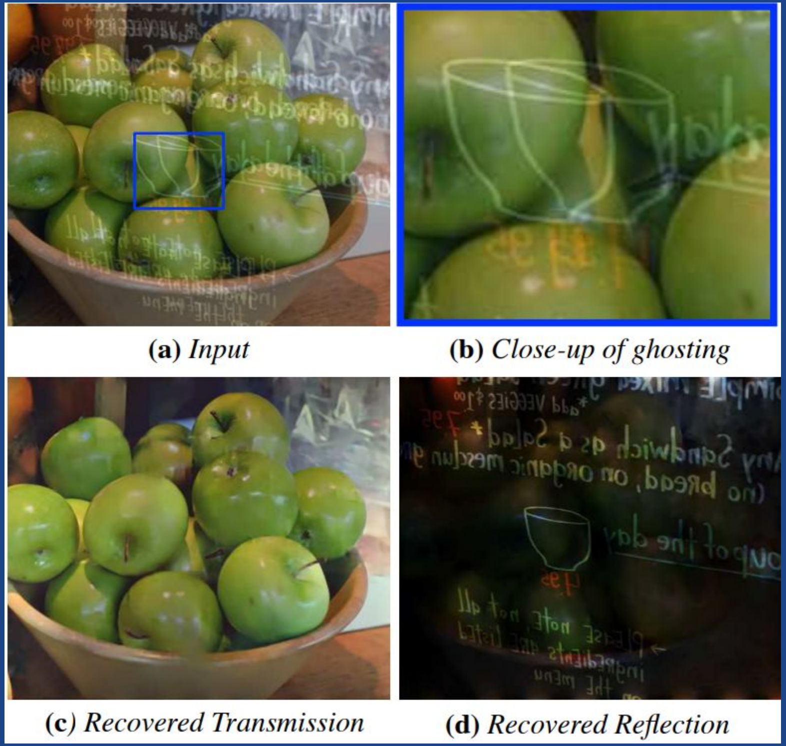


Key Idea Used

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.



(a) *Input* **(b)** *Close-up of ghosting* **(c)** *Recovered Transmission* **(d)** *Recovered Reflection*

Problem Definition

The original image is considered to be composed of a reflection layer (undesirable) and a transmission layer (desirable).

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

where I is Original Image
T is Transmission layer
R is Reflection layer
k is a two-pulse kernel
n is additive Gaussian noise

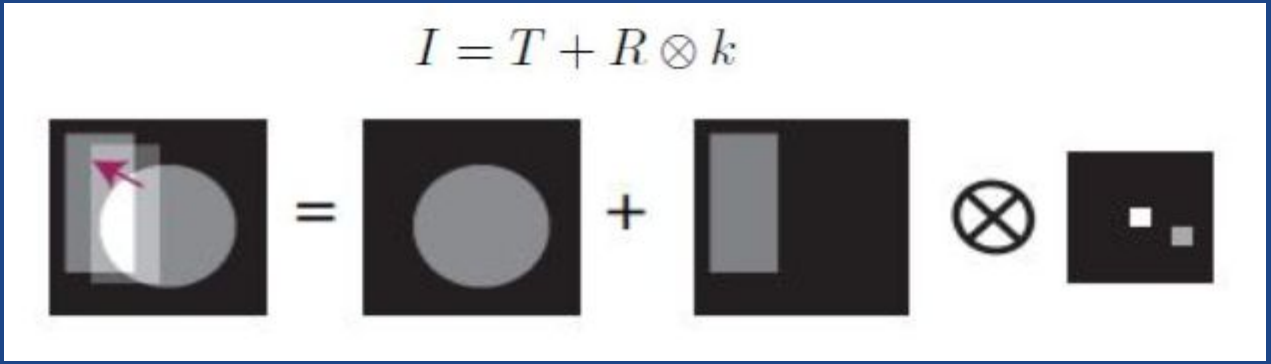
The original image is modeled as a mixture of these layers and the desirable image component is recovered after removing the undesired reflection layer.

Solution Overview

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

Modelling the Ghosting kernel

Using a two pulse kernel k :



Ghosting kernel, k is parameterized by the spatial offset d_k and the attenuation factor c_k.

Layer Separation Algorithm

Given a ghosting kernel k, reconstruction loss using T and R can be expressed as :

$$L(T, R) = \frac{1}{\sigma^2} \|I - T - R \otimes k\|_2^2$$

To regularize this optimization problem, the research paper applies a patch-based prior using a pre-trained Gaussian Mixture Models (GMM). The final combined cost function :

$$\min_{T,R} \quad \frac{1}{\sigma^2} \|I - T - R \otimes k\|_2^2 - \sum_i \log(\mathrm{GMM}(P_i T)) - \sum_i \log(\mathrm{GMM}(P_i R)), \ \text{s.t. } 0 \leq T, R \leq 1$$

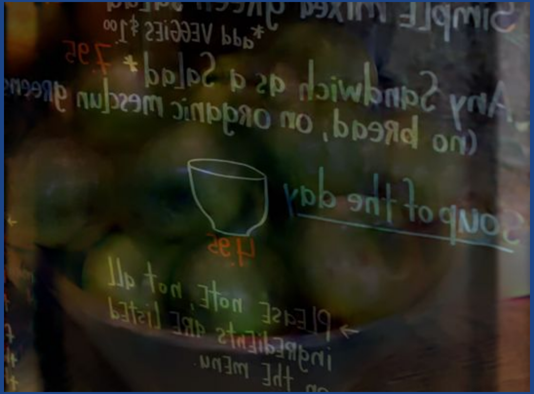
The cost function is non-convex due to the use of the GMM prior. We use an optimization scheme based on half-quadratic regularization.

Post Processing and Results

Using the mean and variance of the original image, we adjust the contrast of the transmitted layer to preserve the flavour of the original image.

Original Image

Transmitted Layer



Reflection Layer

Timeline

Timeline	Milestones
February 14, 2020	• Project Proposal submission • Understand the paper and discussions with the TA. • Reading relevant papers in this domain
Mid-February - March, 2020	• Implementation of the paper with constant TA reviews
April, 2020	• Finalize implementation and demo preparation