BLIND DEBLURRING OF FOREGROUND-BACKGROUND IMAGES

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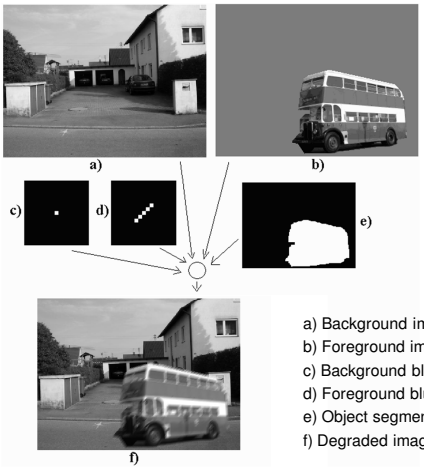
Summary

- We extend the blind deblurring method [1] for separating images with two layers that have suffered different blurs:
  E.g. objects with different velocities, or at different focus depths.
- The method only requires weak assumptions on the blurring filter.
- It reasonably estimates, from a single degraded image:
  - A complete deblurred image (foreground + background)
  - Blurring filters (foreground + background)
  - Segmentation mask between foreground and background.
- Enhancements are achieved both in real blurred photos and in synthetic degradations.

Degradation model



a) Background image - x_1
b) Foreground image - x_2
c) Background blur - h_1
d) Foreground blur - h_2
e) Object segmentation - o
f) Degraded image

Cost function

$$C = \|y - \hat{y}\|_2^2 + \lambda_x [R_f(x_r) + R_f(x_1) + R_f(x_2)] + \lambda_o R_f(o)$$

$R_f(\cdot)$	- Regularizing function - favors sparse edges.
λ_x, λ_o	- Regularizing parameters. $(\lambda_o/\lambda_x = 0.1)$
x_1, x_2	- Foreground and background image estimates.
$\hat{y}$	- Degraded image estimate (degradation model using blur and image estimates).
x_r	- Reconstructed image.
o	- Segmentation estimate
y	- Degraded image

Guided optimization

λ_o, λ_x are initially set to large values and are slowly decreased along iterations:

- Initially, the main features/details are estimated.
- Smaller details are progressively considered as λ_o, λ_x decrease.
- Filter and image estimates improve along iterations.

Image recovered after only 5 iterations

Assumptions (weak)

- Original edges are sparse and sharp.
- Blur operators have limited support.
- A crude initial segmentation is provided.

Algorithm

Initialization:

1 – Set h_1 and h_2 to the identity operator.
2 – Set x_1 and x_2 equal to y.
3 – Initialize o.
4 – Set λ_x, λ_o to the initial values of their sequences.

Optimization loop:

5 – Find new estimates for x_1 and x_2:
$(x_1, x_2) = \text{argmin}_{x_1,x_2}\, C(x_1, x_2, h_1, h_2, o)$
6 – Find a new estimate for o:
$o = \text{argmin}_o\, C(x_1, x_2, h_1, h_2, o)$
7 – Find new estimates for h_1 and h_2:
$(h_1, h_2) = \text{argmin}_{h_1,h_2}\, C(x_1, x_2, h_1, h_2, o)$
8 – Set λ_x, λ_o to the next values in sequence.
9 – If $\lambda_x \geq \lambda_{x_{min}}$ go back to 5; otherwise stop.

Inputs

Degraded image

Manual segmentation

Degraded image

Manual segmentation

Degraded image

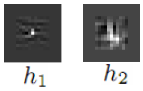
Manual segmentation

Estimates

x_r

h_1 h_2

x_r



h_1 h_2

x_r

h_1

h_2

Conclusions

- The blind deblurring method of [1] is extended to foreground-background images.
- As in [1], the method only requires weak assumptions on the blurring filters.
- Satisfactory reconstruction is obtained on synthetic degraded images and on real photos.

References

[1] M. S.C. Almeida and L. B. Almeida, "Blind and semi-blind deblurring of natural images," IEEE Trans. Image Processing, 2009.

[2] M. Figueiredo, D. Cheng, and V. Murino, "Clustering under prior knowledge with application to image segmentation," in NIPS, 2006. (for the initial segmentation estimate)