

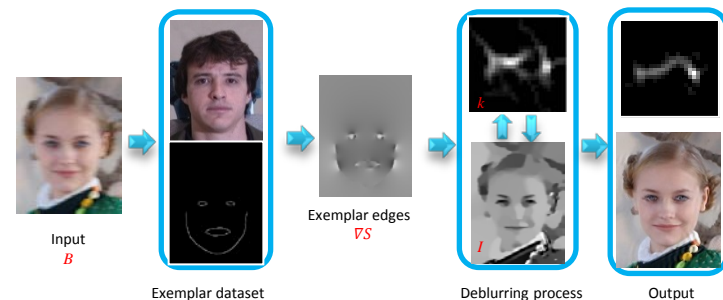
Introduction

Goal: recover clear face images from blurry ones

Challenges:

- Not much texture in the blurry face image
- Ambiguous edges caused by blur
- Implicit or explicit restoration of salient edges are difficult
- Relying on local salient-edge restoration

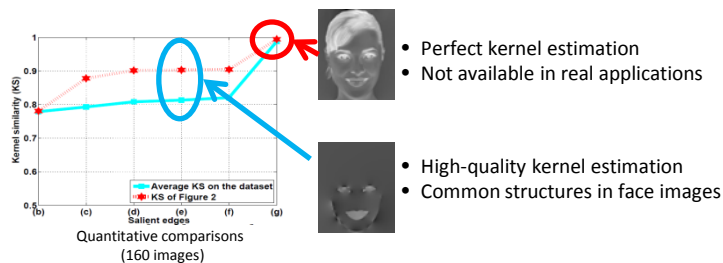
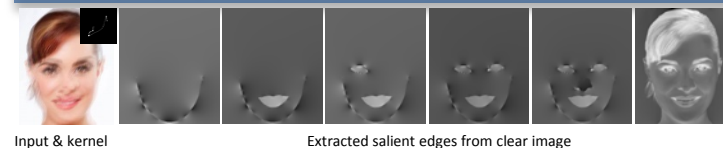
Algorithm Overview



Approach:

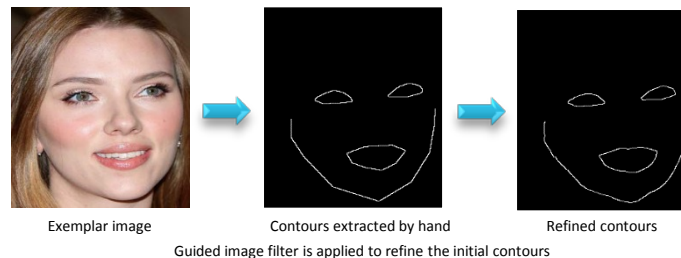
- Extract global exemplar structure
- Find the best matched exemplar edges for input image
- Guide kernel estimation with exemplar edges

What Structure Is Useful?



Exemplar Structure

- Collect 2,435 face images (with landmarks) from the CMU PIE dataset of different identities, facial expressions and poses
- Manually extract informative structures (lower contour, eyes, and mouth)
- Refine contours using guided filter



Extract Salient Edges

- Find the best matched exemplar

$$v_i = \max_t \frac{\sum_x \nabla B(x) \nabla T_i(x+t)}{\|\nabla B(x)\|_2 \|\nabla T_i(x+t)\|_2}$$

where i is the index of the exemplar, $\nabla T_i(x)$ is the i -th exemplar, and t is the possible shift between image gradients $\nabla B(x)$ and $\nabla T_i(x)$.

- Salient edges computation

$$\nabla S = \begin{cases} \nabla T_{i^*}(x), & \text{if } x \in \{x | M_{i^*}(x) = 1\} \\ 0, & \text{otherwise} \end{cases}$$

where $i^* = \arg \min_i v_i$ and $M_{i^*}(x)$ is the contour mask for i^* -th exemplar.

Kernel Estimation Process

- Alternatively solving

$$\nabla I \rightarrow \nabla S \begin{cases} \min_k \|\nabla S * k - \nabla B\|^2 + \gamma \|k\|^2 \\ \min_l \|\nabla I * k - B\|^2 + \lambda \|\nabla I\|_0 \end{cases}$$

References

- [1] S. Cho, S. Lee. Fast motion deblurring. In SIGGRAPH Asia, 2009
- [2] L. Xu, S. Zheng, and J. Jia. Unnatural l_0 sparse representation for natural image deblurring. In CVPR, 2013
- [3] D. Krishnan, T. Tay, R. Fergus. Blind deconvolution using a normalized sparsity measure. In CVPR, 2011

Experimental Results

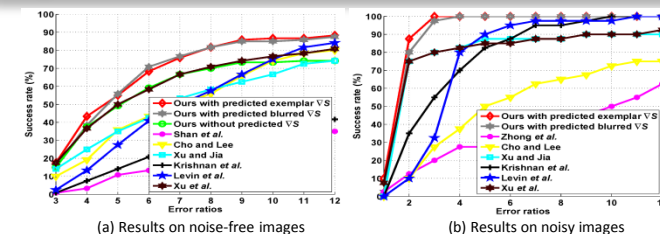
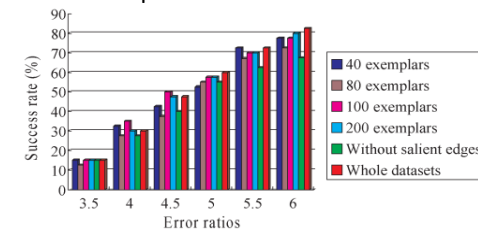
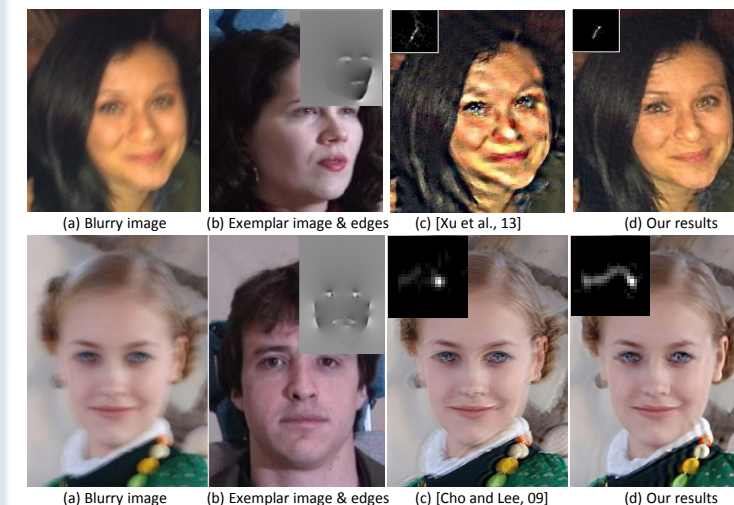


Fig. Quantitative comparisons on 480 blurred images

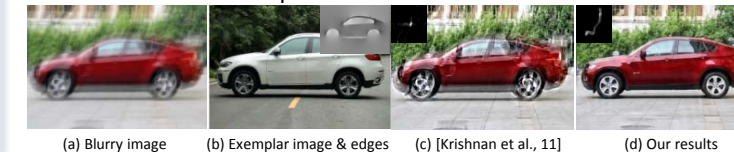
- Robustness to Exemplar Set Size



- Comparisons with State-of-the-Art Methods



- Extension of the Proposed Method



* indicates equal contribution