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Challenges
- Single image reflection removal:
  - Underdetermined, weighted combination of scenes from the two sides of glass window.
  - Lacking plenty of reflection and clear image pairs for training the deep neural network.
  - Naively mixing two natural images by scaling different layers with weights summed to 1 does not work!
- Image smoothing:
  - Slow running time of traditional image smoothers.
  - Approximation of existing edge-aware filters with deep networks: Unsatisfactory quality (PSNR < 35).

Observation
- Edge information plays a very important role in many low-level vision tasks, such as:
  - layer separation (reflection removal)
  - Image filtering (image smoothing)

Contribution 1: Cascaded Edge and Image Learning Network (CEILNet)
Instead of predicting images directly, we separate the end-to-end FCN into two sub networks:
- Target edge prediction
- Target image reconstruction
Both tasks are much more easier and learned with the similar CNN structure, 32-layer FCN.

Contribution 2: Reflection Image Synthesis Pipeline
1. $\mathbf{R} \leftarrow \text{gauss\_blur}_\sigma(\mathbf{R})$ with $\sigma \sim \mathcal{U}(2,5)$
2. $\mathbf{I} \leftarrow \mathbf{R} + \mathbf{B}$
3. $m \leftarrow \text{mean}((f(x,c)|f(x,c) > 1, \forall x, \forall c = 1,2,3))$
4. $\mathbf{R}(x,c) \leftarrow \mathbf{R}(x,c) - \gamma \cdot (m - 1), \forall x, \forall c; \gamma \text{ set as 1.3}$
5. $\mathbf{R} \leftarrow \text{Clip}_{[0,1]}(\mathbf{R})$
6. $\mathbf{I} \leftarrow \text{Clip}_{[0,1]}(\mathbf{B} + \mathbf{R})$

Note $m$ is adaptively-computed, and subtracted by $\mathbf{R}$.

Ablation Study of Deep Network
Demonstration of necessity of I-CNN by replacing it with traditional method Domain Transform (DT), and importance of E-CNN by using I-CNN only.

Performance Evaluation of Reflection Removal Task
- Guess which is real and which is synthetic?

Performance Evaluation of Image Smoothing Task

Codes and model: https://github.com/fqnchina/CEILNet