Single Image Reflection Suppression

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Introduction

Automatically removing reflections from a single image is a highly ill-posed problem. We propose an efficient solution that performs better than the state-of-the-art. We propose to suppress reflections using an optimization objective based on the $\ell_1$ gradient prior. We use a modified data fidelity term based on the Laplacian operator in order to maintain structures of high detail. Our algorithm provides state-of-the-art results in reflection removal in several realistic scenarios.

\begin{equation}
\begin{split}
Y &= T + R \\
Y &\in \mathbb{R}^{m \times n} : \text{image with reflections} \\
T &\in \mathbb{R}^{m \times n} : \text{transmission image} \\
R &\in \mathbb{R}^{m \times n} : \text{reflection image}
\end{split}
\end{equation}

We observe that reflection edges are smaller in magnitude and less in focus than transmission edges. With $k$ as a blurring kernel and $W$ as the contribution weights of the transmission, we state:

\begin{equation}
Y = W \circ T + (1 - W) \circ (k \ast R)
\end{equation}

To better retain continuity of image structures, we use the $\ell_0$ prior on the image gradients

\begin{equation}
T^* = \arg \min_{T} \left\{ \|L(T) - L(Y)\|_2^2 + \lambda C(T) \right\}
\end{equation}

\begin{equation}
C(T) = \# \{i, j : |\nabla_x T_{ij}| + |\nabla_y T_{ij}| \neq 0 \}
\end{equation}

The optimization objective is minimized using the variable splitting approach of [Xu et al., 2011]:

\begin{equation}
\begin{split}
T^*, G^* &= \arg \min_{T, G} \left\{ \|L(T) - L(Y)\|_2^2 + \lambda C(G) + \beta \| \nabla T - G \|_2^2 \right\}
\end{split}
\end{equation}

Evaluation

Comparison of reflection removal methods on real-world images. Our method gives superior color reproduction over [Li and Brown, 2014] and reflection suppression over [Wan et al., 2016].

References

