# Joint Demosaicing and Chromatic Aberration Correction Using Neural Networks

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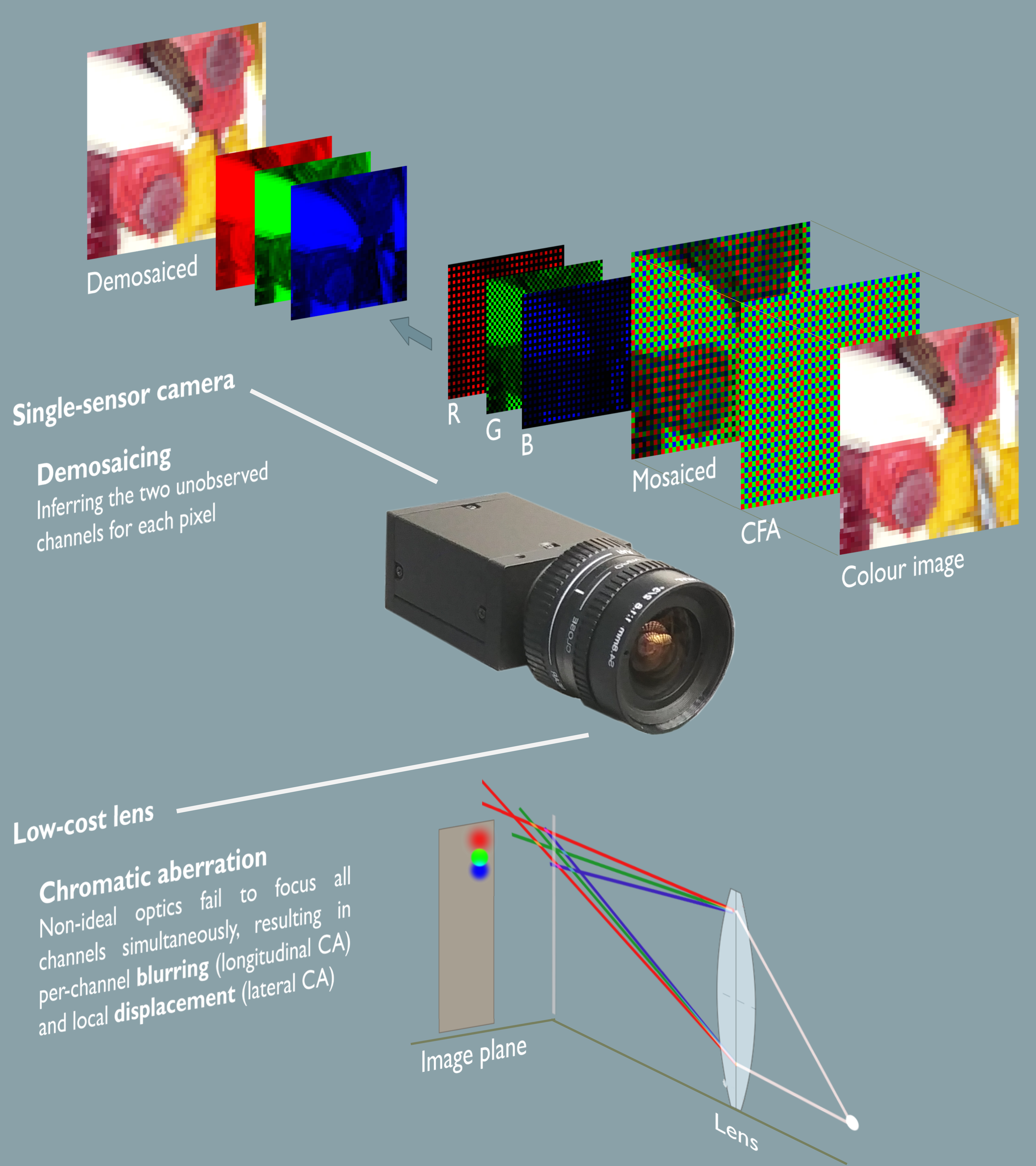
## Overview

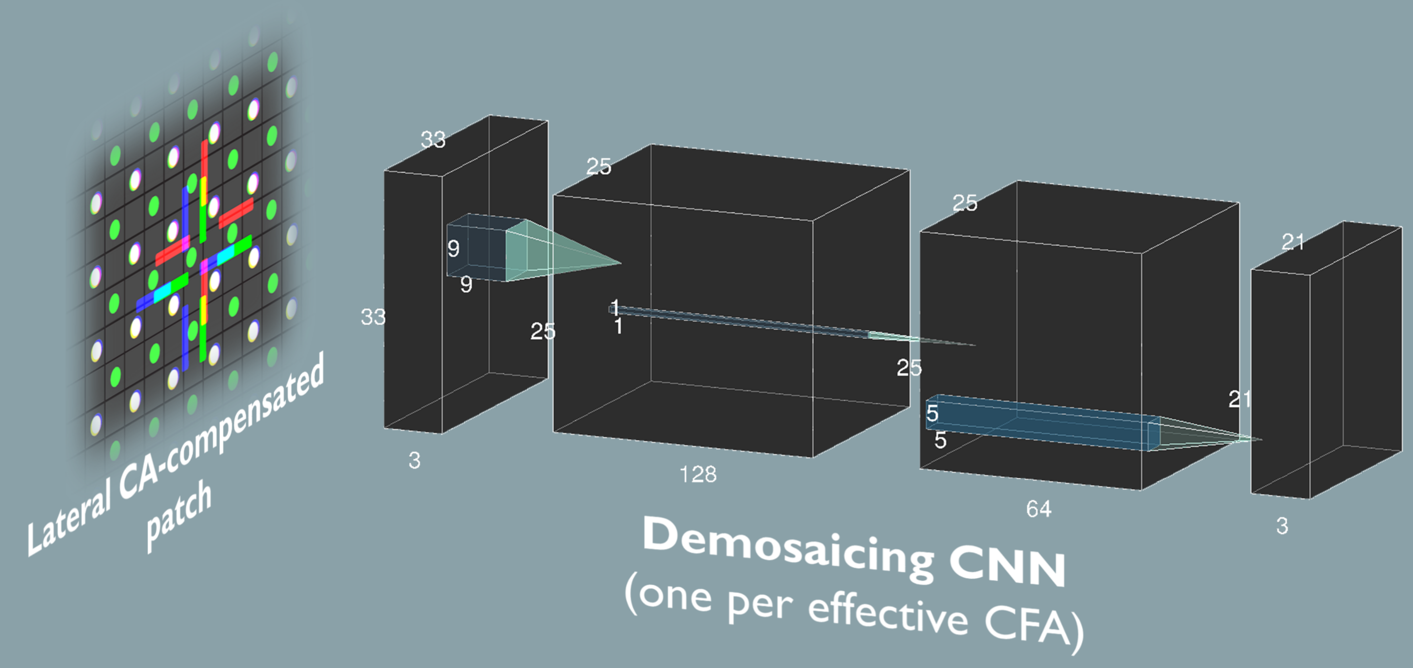
- *Typical cameras feature a single sensor with a colour filter array (CFA). Through* ***demosaicing (DM)****, the two unobserved channels for each pixel are estimated, producing an RGB image.*
- *Low-cost lenses suffer from* ***chromatic aberration (CA)****, effectively a per-channel displacement and blurring, causing objectionable colour fringing around edges and furthermore confounding edge-directed DM.*
- *We propose a neural network-based* ***joint DM and CA correction*** *approach which improves reconstruction quality compared to the edge-directed baseline, preserving image detail and minimizing artifacts, even under severe CA.*




## Approach

Our approach is based on the demosaicing convolutional neural network (DMCNN) of [4], in which 33x33 patches of a CFA mosaiced input image are passed through a network with three convolutional layers to reconstruct RGB colour patches. To account for the variation in lateral CA over the image, we train six such networks, each specialized to one 'effective CFA', where the effective CFA represents the grid of colour channels active after displacing (to the nearest pixel) the red and blue channels of the CFA pattern so as to reverse the local displacement caused by lateral CA. After symmetries, there are six such effective CFAs.

Effective CFAs

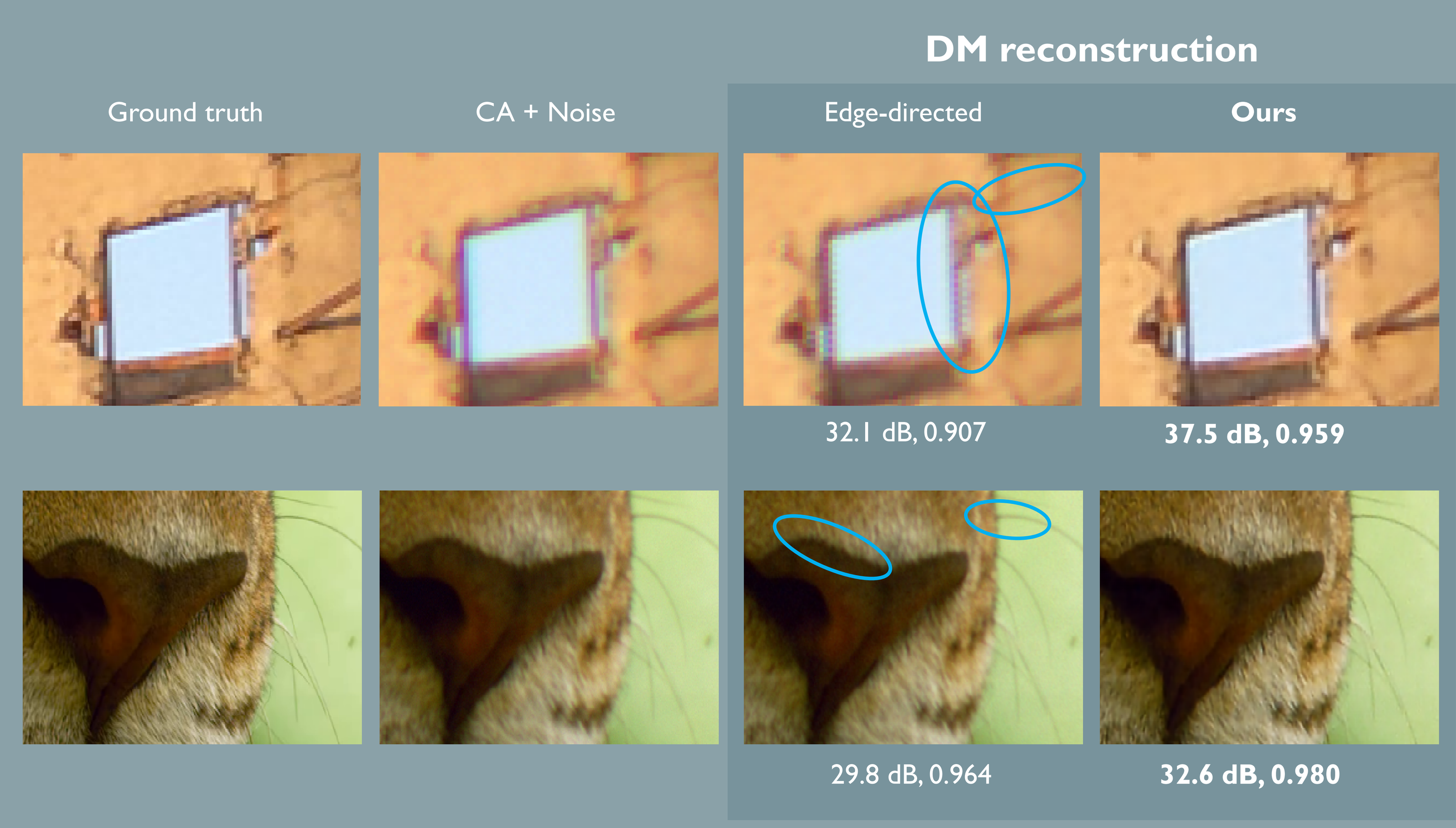



## Results

Performing DM and CA correction jointly using the proposed neural network-based approach with the 'Holiday' dataset [1], yields image reconstructions with higher PSNR and SSIM and with fewer visual artifacts than with reconstruction using edge-directed interpolation [2]. The proposed approach could be applied in the production of high-quality images and video from machine vision cameras with low cost lenses, thus extending the viability of such hardware to visual media production.

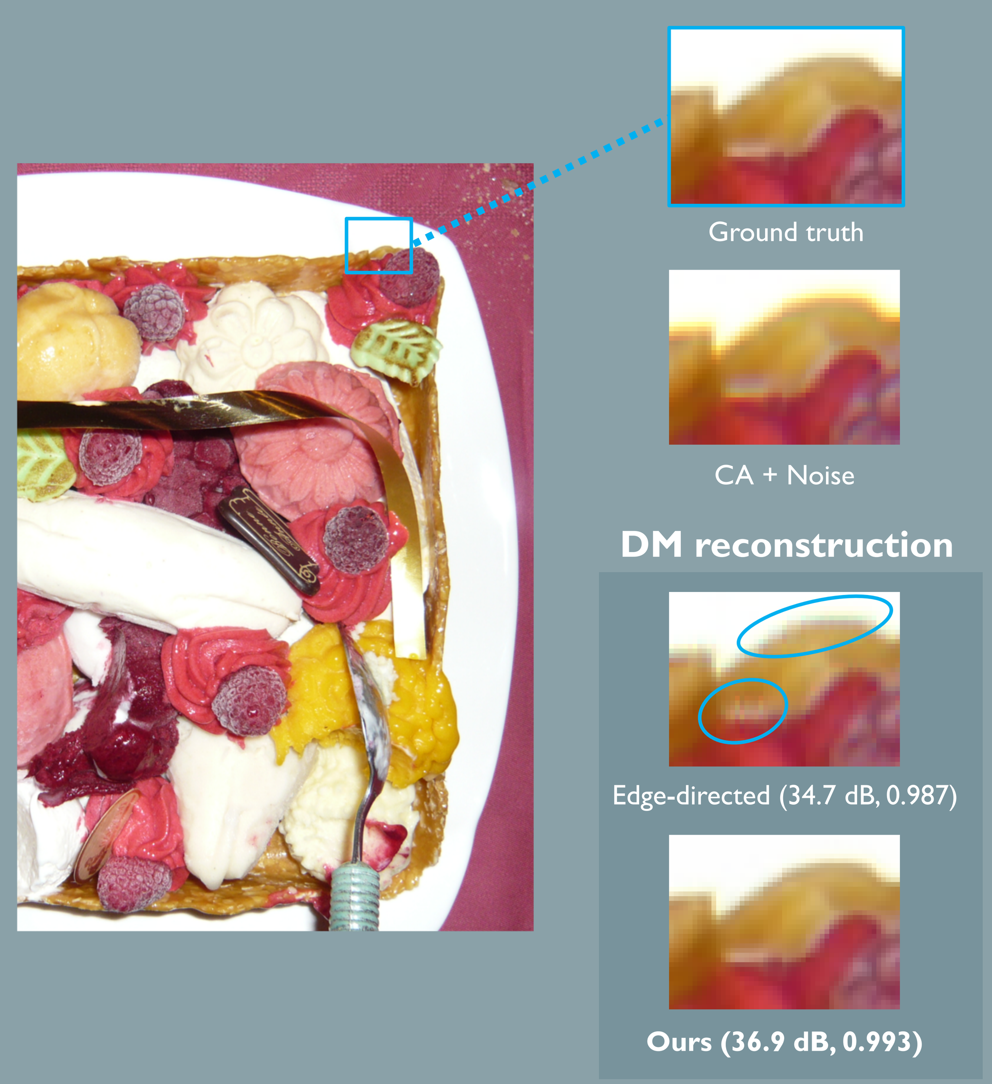
**Overall reconstruction error on 'Holiday' dataset**

| | *Mean (std) PSNR (dB)* | | | *Mean (std) SSIM* | | |
|---|---|---|---|---|---|---|
| | *CA+Noise* | *Edge-Dir* | ***Ours*** | *CA+Noise* | *Edge-Dir* | ***Ours*** |
| Light CA | 31.5 (4.3) | 32.9 (4.2) | **35.8 (3.4)** | 0.9364 (0.045) | 0.9507 (0.034) | **0.9746 (0.015)** |
| Heavy CA | 27.4 (3.3) | 28.4 (3.4) | **32.5 (2.9)** | 0.8383 (0.085) | 0.8655 (0.076) | **0.9389 (0.031)** |




## Motivation

Widely-used demosaicing approaches, e.g. [2], exploit the co-location of edges across channels. However, their performance is degraded in the presence of strong chromatic aberration since edges are no longer aligned across colour channels. When CA correction is performed after DM, artifacts from the DM are propagated to the final image, resulting in colour fringing and comb artifacts. By jointly performing DM and CA correction, performance can be improved, while maintaining image detail.

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## References

[1] Herve Jegou, Matthijs Douze, and Cordelia Schmid. Hamming embedding and weak geometric consistency for large scale image search. In European Conference on Computer Vision (ECCV), pages 304–317, 2008.

[2] Rico Malvar, Li-wei He, and Ross Cutler. High-quality linear interpolation for demosaicing of bayer-patterned color images. In Int. Conference of Acoustic, Speech and Signal Processing, 2004.

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[4] Nai-Sheng Syu, Yu-Sheng Chen, and Yung-Yu Chuang. Learning deep convolutional networks for demosaicing. CoRR, abs/1802.03769, 2018. URL http://arxiv.org/abs/1802.03769.