ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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COMPRESSIVE ACQUISITION OF COLOR AND NEAR-INFRARED IMAGES

Abstract

We propose using a single silicon sensor and a modified Bayer CFA for joint acquisition of color and near-infrared (NIR) images. Silicon sensors, which are placed in most color cameras, are inherently sensitive to NIR. Hence, our proposed design is very similar to consumer color cameras in terms of hardware. The main contribution of this work is an algorithm that estimates full-resolution color and NIR images from subsampled and mixed sensor measurements. Our method results in high-quality RGB and NIR images.

Motivation

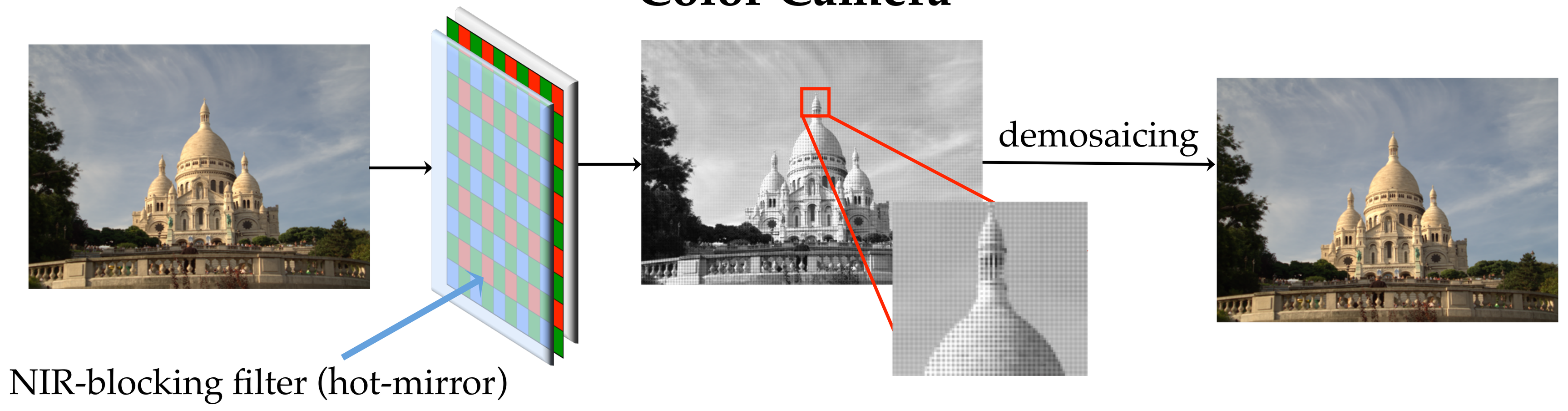
Applications of combining color and NIR images

Image dehazing | Skin smoothing | Shadow detection | Object segmentation | Semantic segmentation

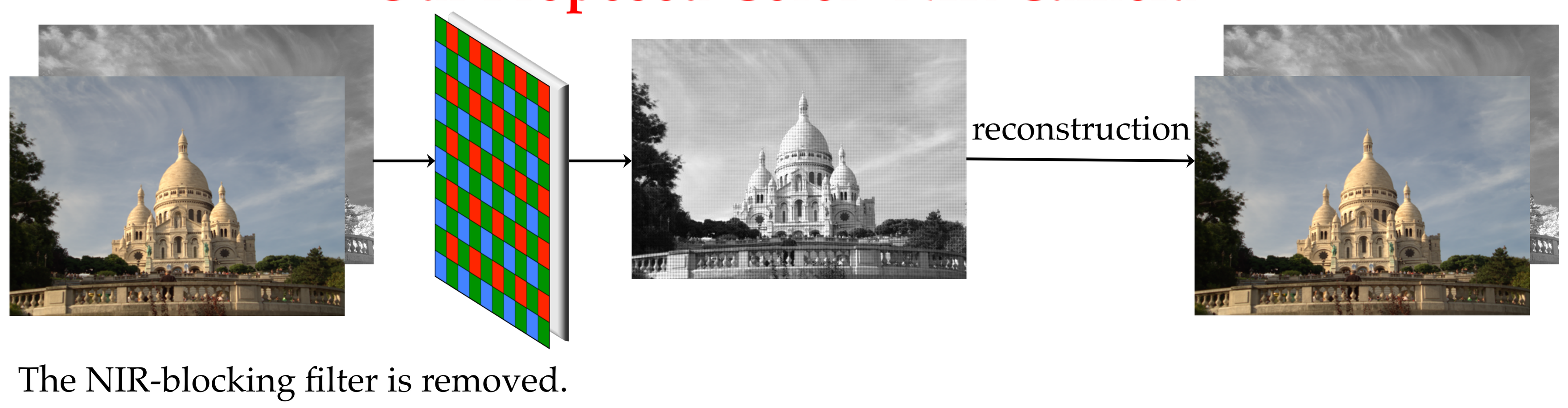
Goal

Our main goal is to design an RGB and NIR imaging system that requires least amount of hardware modification in current color cameras. Such a design does not impose additional manufacturing costs.

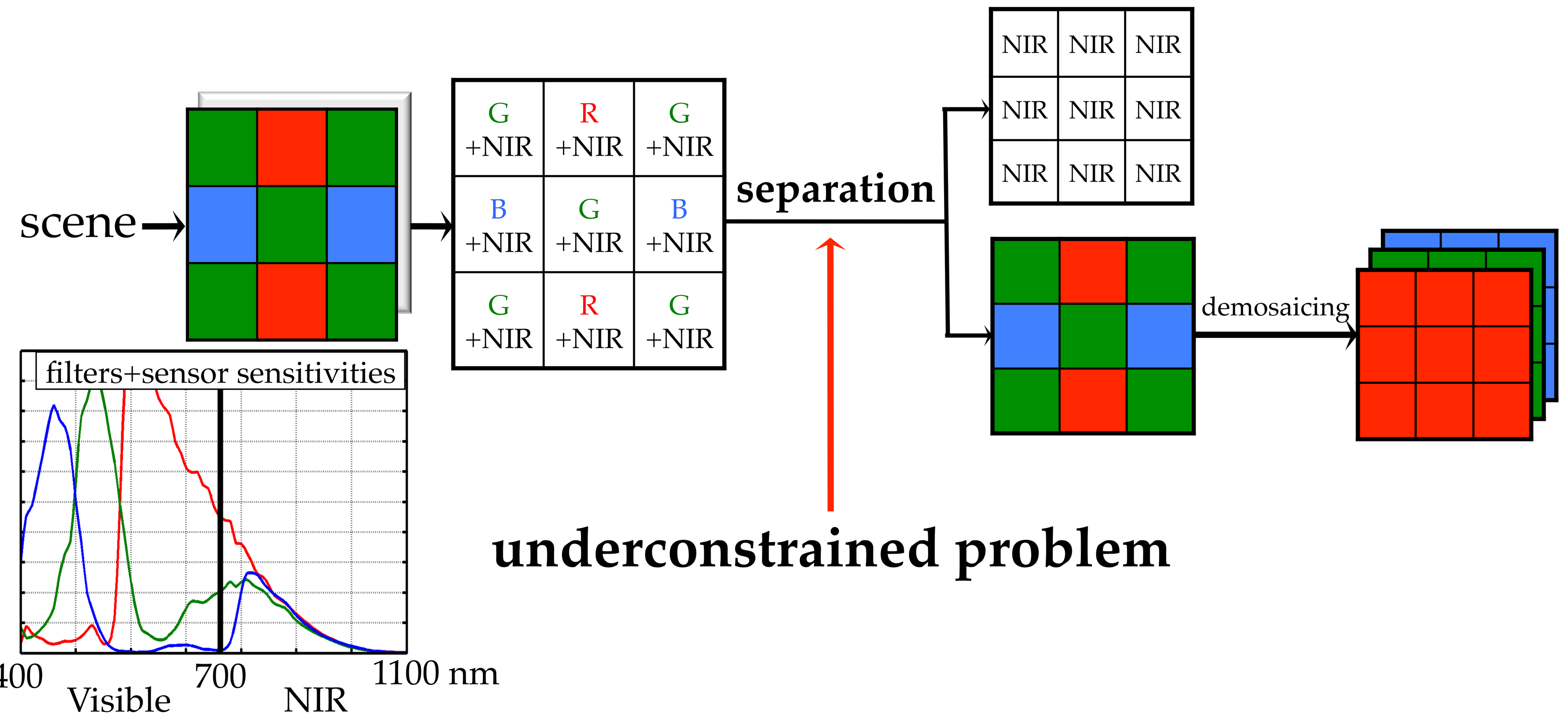
Color Camera



Our Proposed Color+NIR Camera

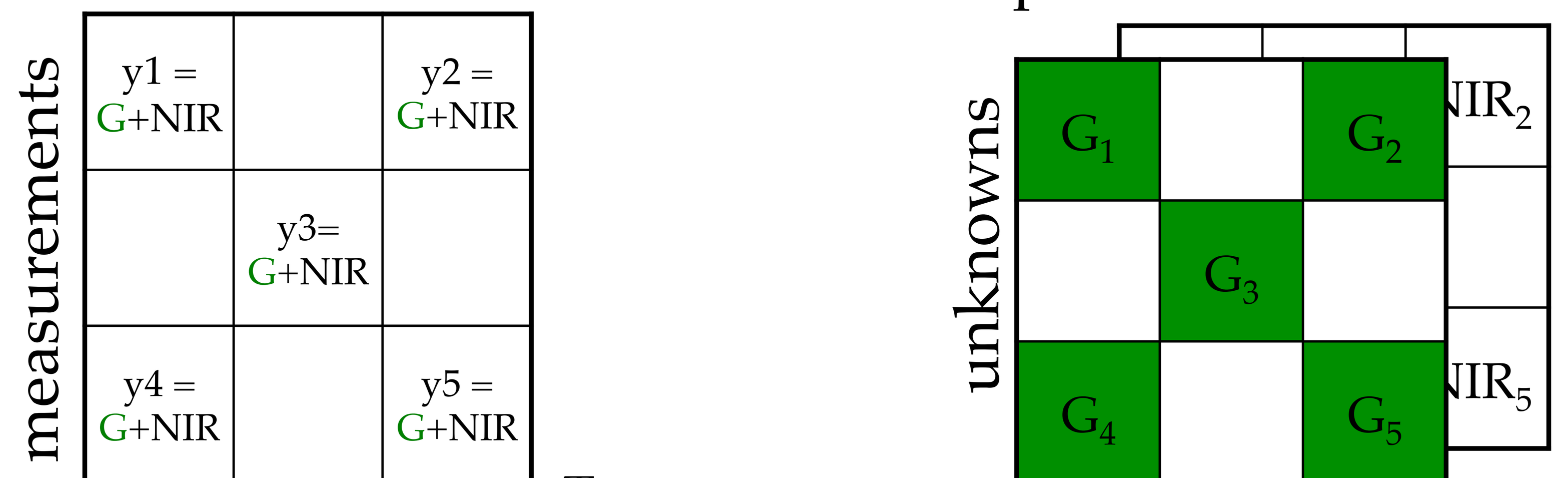


Proposed Algorithm



The Separation Algorithm

1. Green and NIR separation



$\boldsymbol{y} = [y_1, y_2, \cdots, y_5]^T$ $\boldsymbol{x} = [\mathrm{G}_1, \mathrm{NIR}_1, \cdots, \mathrm{G}_5, \mathrm{NIR}_5]^T$

$$\boldsymbol{y} = \boldsymbol{M}\boldsymbol{x}$$

Impose the sparsity constraint to find the unique solution:

$$\boldsymbol{s}^\star = \mathrm{argmin}\ \|\boldsymbol{s}\|_0 \quad \text{s.t. } \boldsymbol{y} = \boldsymbol{M}\boldsymbol{\Phi}\boldsymbol{s} \longrightarrow \boldsymbol{x}^\star = \boldsymbol{\Phi}\boldsymbol{s}^\star$$

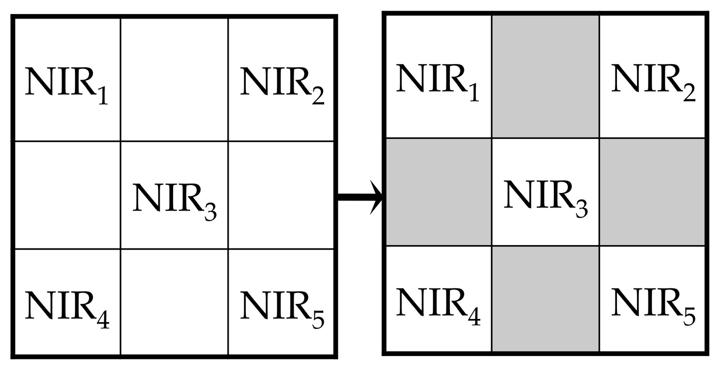
$$M = \begin{bmatrix} \alpha_1 & \beta_1 & 0 & 0 & \cdots & 0 \\ 0 & 0 & \alpha_2 & \beta_2 & \cdots & 0 \\ \vdots & & & & & \end{bmatrix}$$

$\boldsymbol{\Phi}$: the sparsifying transform

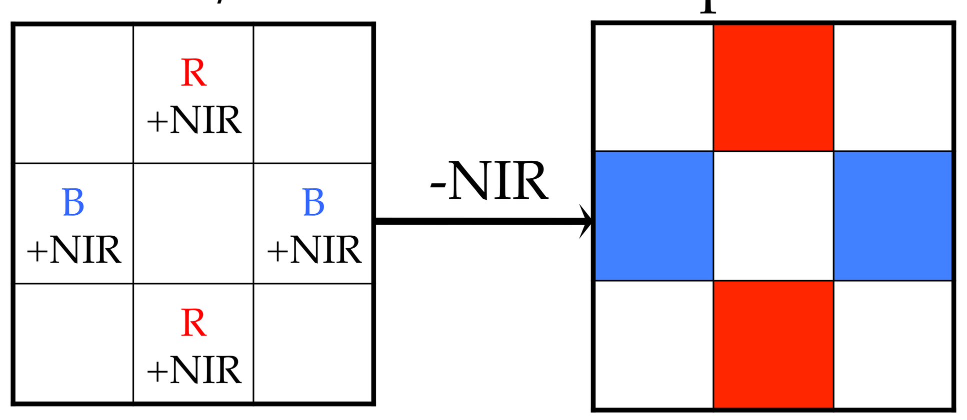
$$\boldsymbol{\Phi} = \boldsymbol{D}_{\mathrm{PCA}} \times \boldsymbol{D}_{\mathrm{DCT}}$$

$\alpha_1, \alpha_2, \beta_1, \beta_2$: optimized on a training set

2. NIR interpolation



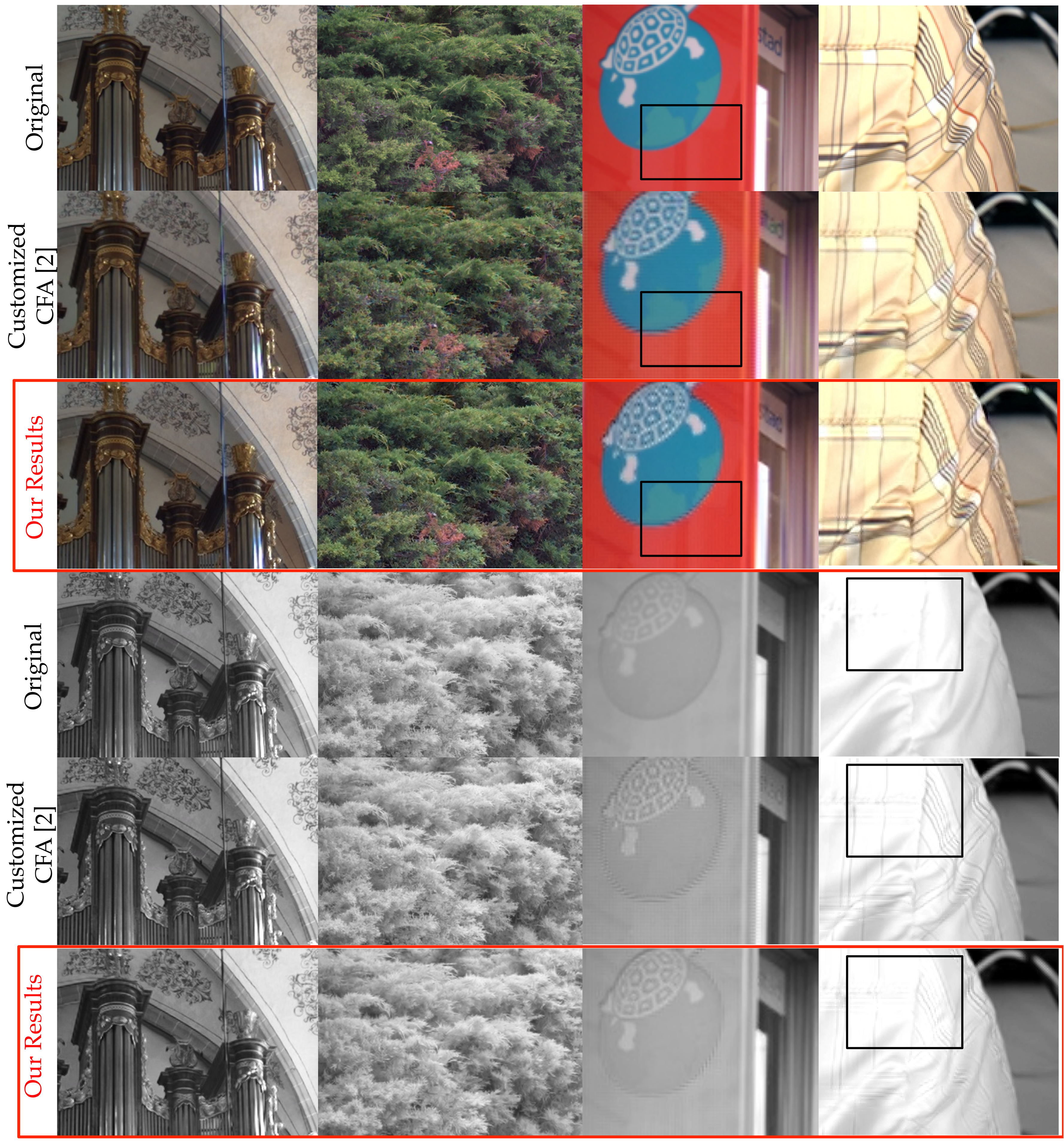
3. Red/Blue and NIR separation



More details about the algorithm in [1].

http://ivrg.epfl.ch/people/kermani

Simulation Results



Rows 1-3: color and rows 4-6: NIR images.
The customized CFA algorithm is presented in [2].

Acknowledgment

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References

[1] Z. Sadeghipoor, Y. Lu, and S. Süsstrunk, "A novel compressive sensing approach to simultaneously acquire color and near-infrared images on a single sensor," ICASSP 2013.

[2] Y. M. Lu, C. Fredembach, M. Vetterli, and S. Süsstrunk, "Designing color filter arrays for the joint capture of visible and near-infrared images," ICIP 2009.