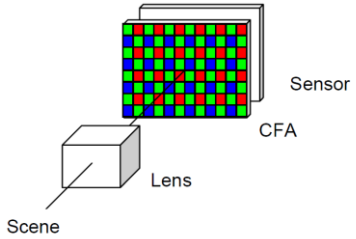
OS T5.3 Image/Video processing

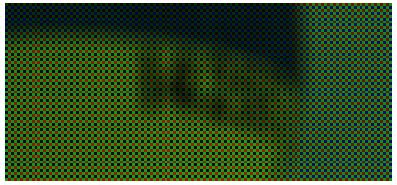
D^3Net: Joint Demosaicking, Deblurring and Deringing

Tomas Kerepecky and Filip Sroubek

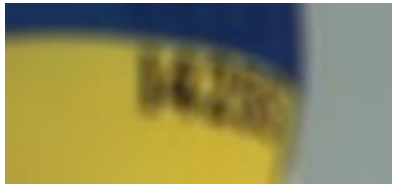
Institute of Information Theory and Automation
The Czech Academy of Sciences
Prague, Czechia

The path to a white-box network



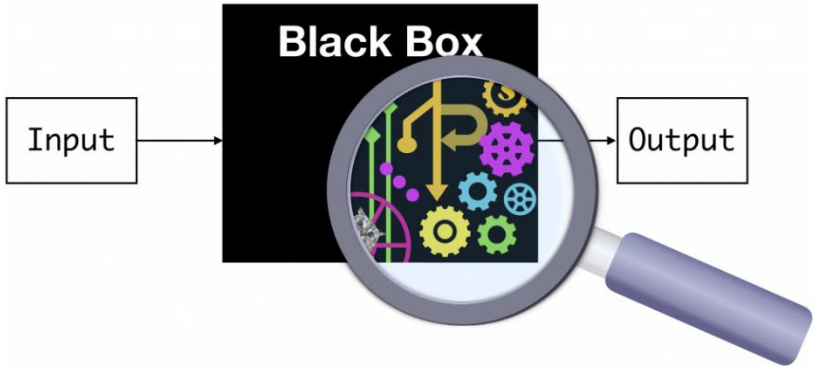


CFA pattern



Blurred image

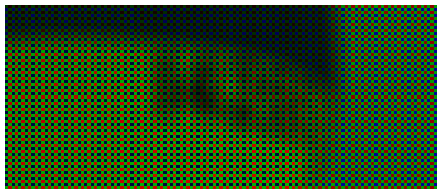
Ringing



1. joint three restoration tasks
2. light-weight architecture
3. transparent CNN

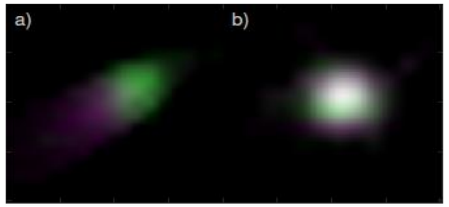
Image degradation model

Degraded data by blur,
CFA pattern and noise



Blurred image

$$g = SHu + n$$



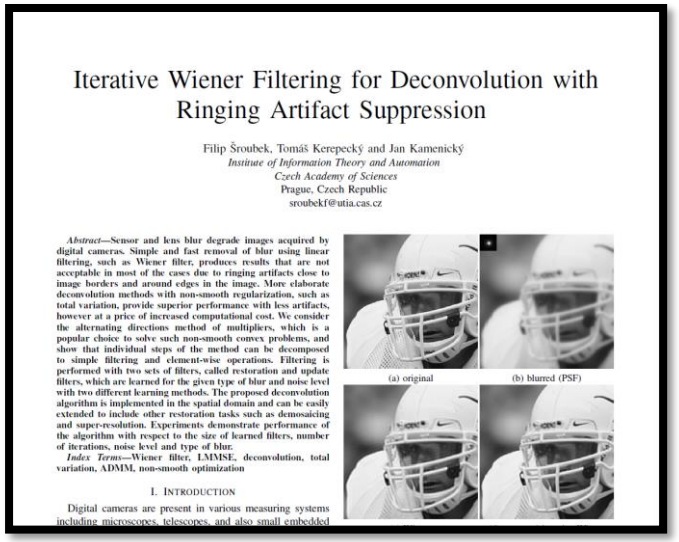
Intrinsic camera blur

Original image

Model-based solution

Optimization problem with total variation regularization

$$\hat{u} = \arg\min_{u} \frac{\gamma}{2} \|SHu - g\|_2^2 + \phi^1\left(\{D_j u\}\right)$$



Iterative Wiener Filtering for Deconvolution with Ringing Artifact Suppression

Filip Šroubek, Tomáš Kerepecký and Jan Kamenický
Institute of Information Theory and Automation
Czech Academy of Sciences
Prague, Czech Republic
sroubekf@utia.cas.cz

***Abstract*—Sensor and lens blur degrade images acquired by digital cameras. Simple and fast removal of blur using linear filtering, such as Wiener filter, produces results that are not acceptable in most of the cases due to ringing artifacts close to image borders and around edges in the image. More elaborate deconvolution methods with non-smooth regularization, such as total variation, provide superior performance with less artifacts, however at a price of increased computational cost. We consider the alternating directions method of multipliers, which is a popular choice to solve such non-smooth convex problems, and show that individual steps of the method can be decomposed to simple filtering and element-wise operations. Filtering is performed with two sets of filters, called restoration and update filters, which are learned for the given type of blur and noise level with two different learning methods. The proposed deconvolution algorithm is implemented in the spatial domain and can be easily extended to include other restoration tasks such as demosaicing and super-resolution. Experiments demonstrate performance of the algorithm with respect to the size of learned filters, number of iterations, noise level and type of blur.**

***Index Terms*—Wiener filter, LMMSE, deconvolution, total variation, ADMM, non-smooth optimization**

(a) original (b) blurred (PSF)

I. Introduction

Digital cameras are present in various measuring systems including microscopes, telescopes, and also small embedded

IWFT: Sroubek 2019

Using ADMM leads to an iterative solution

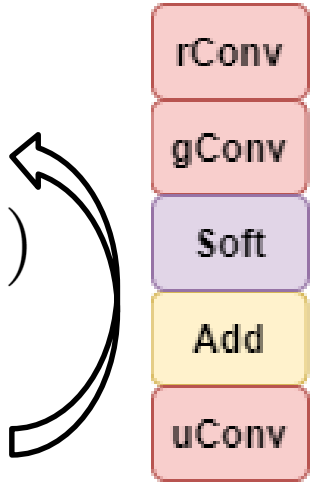
Model-based solution

Optimization problem with total variation regularization

$$\hat{u} = \arg\min_u \frac{\gamma}{2}\|SHu - g\|_2^2 + \phi^1\left(\{D_j u\}\right)$$

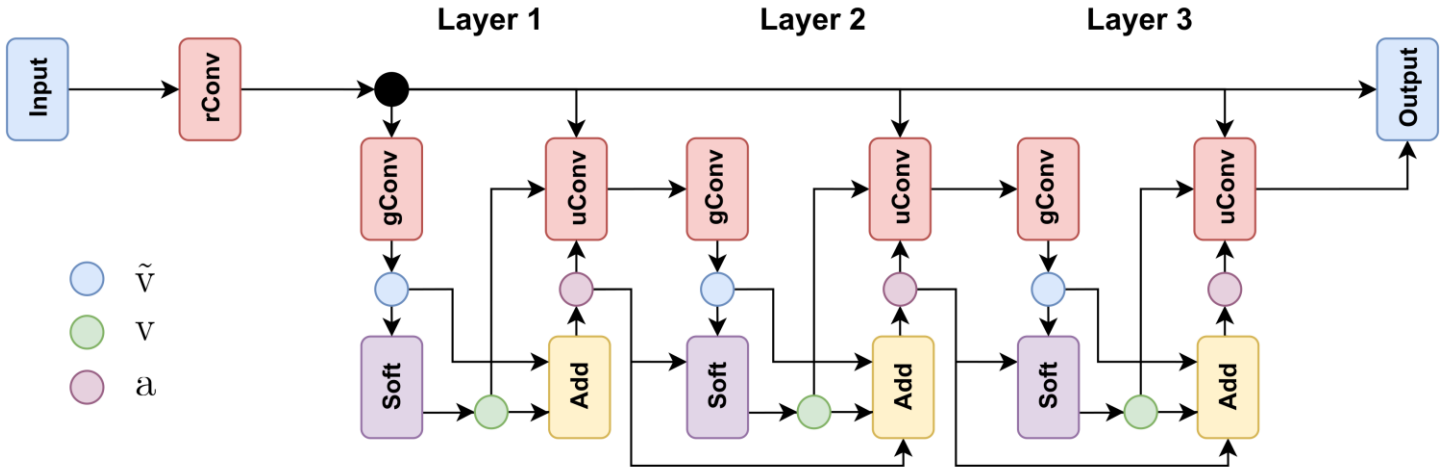
$$\hat{u}_0 = P(r * g)$$
$$\tilde{v}_i = d * \hat{u}_{i-1}$$
$$v_i = \texttt{SoftThr}\left(\tilde{v}_i - a_{i-1}\right)$$
$$a_i = a_{i-1} + \left(v_i - \tilde{v}_i\right)$$
$$\hat{u}_i = \hat{u}_0 + w * \left(v_i + a_i\right)$$

Initial restoration

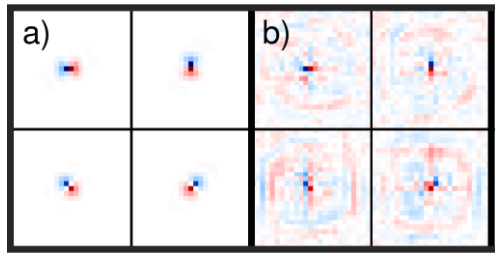


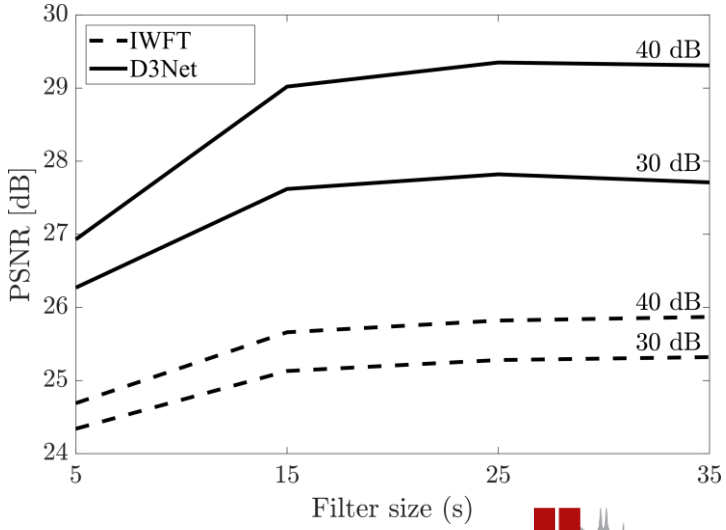
only filtering and element-wise operations

D^{3}Net is inspired by model-based optimization algorithm

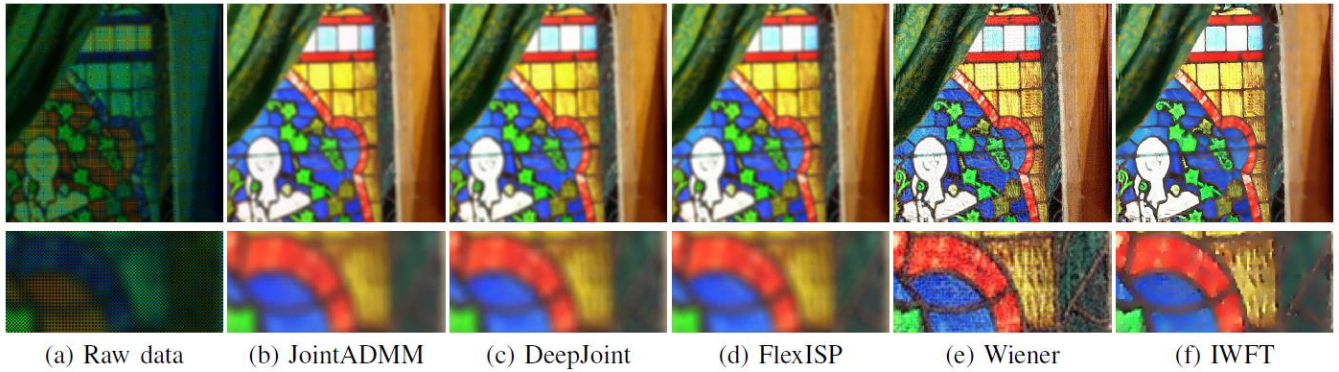


Filters are improved by learning





Joint vs. sequential approach



(a) Raw data (b) JointADMM (c) DeepJoint (d) FlexISP (e) Wiener (f) IWFT

(g) Ground-truth (h) JointADMM* (i) DeepJoint* (j) FlexISP* (k) D^{3}Net v1 (l) D^{3}Net v2

OUT-OF-FOCUS BLUR: AVERAGE PSNR AND SSIM RESULTS FOR THE DIFFERENT RECONSTRUCTION METHODS.

Method	PSNR [dB]	SSIM
JointADMM	23.06	0.742
DeepJoint	23.40	0.751
FlexISP	23.37	0.763
Wiener	23.57	0.826
IWFT	24.07	0.843
JointADMM*	25.44	0.839
DeepJoint*	25.62	0.846
FlexISP*	26.48	0.882
D^{3}Net v1	27.61	0.887
D^{3}Net v2	**28.91**	**0.912**

Phone demosaicking

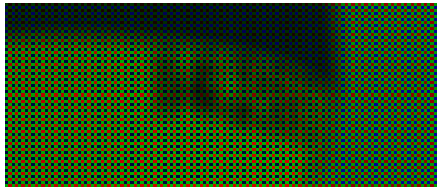
D^{3}Net

Real data

Conclusion

1. joint three restoration tasks

Demosaicking

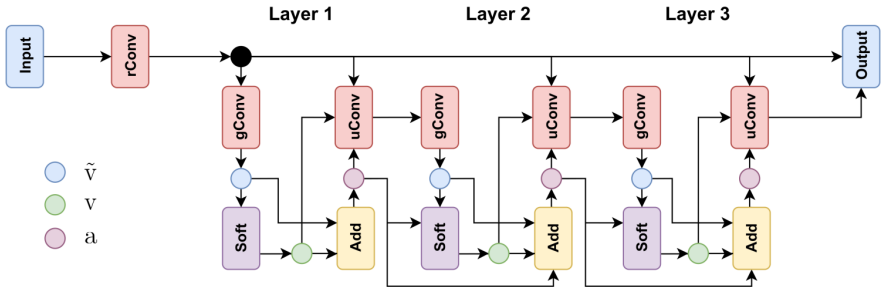


Deblurring

Deringing

2. light-weight architecture

3. transparent CNN



Thank you for your attention

Tomas Kerepecky

kerepecky@utia.cas.cz

http://zoi.utia.cas.cz & www.kerepecky.eu