A Pipeline for Lenslet Light Field Quality Enhancement
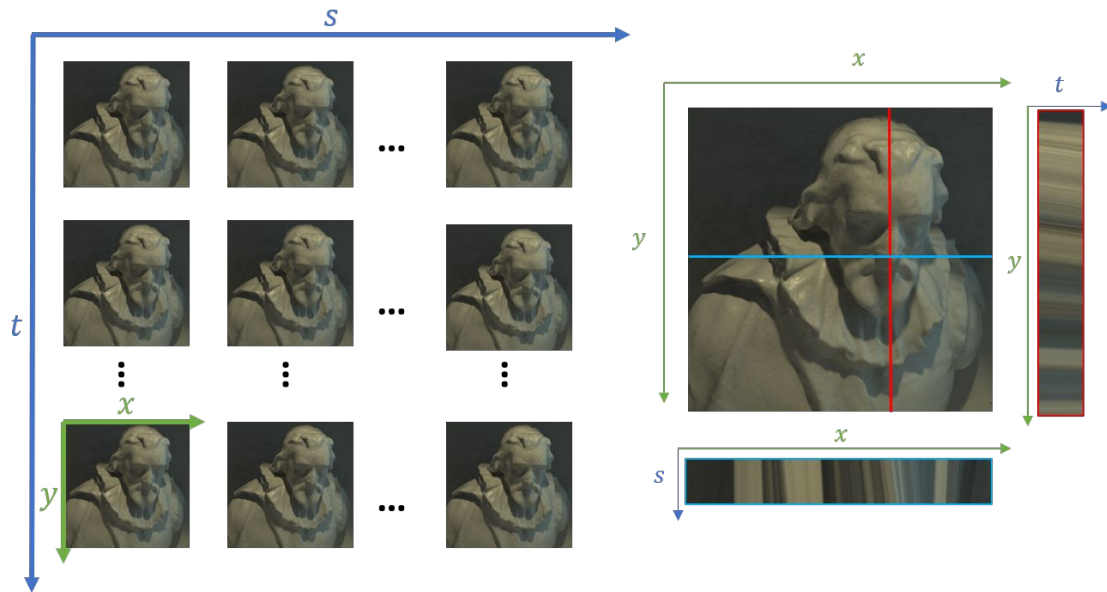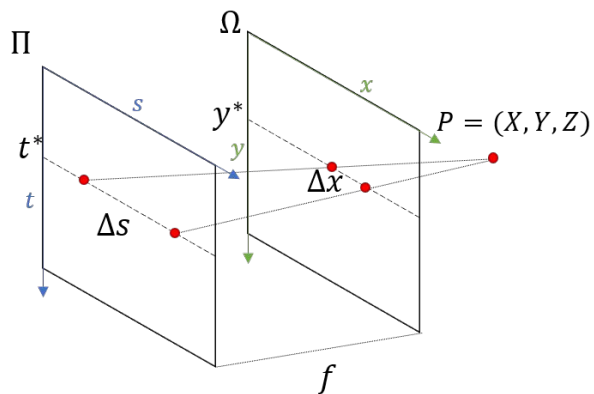
Pierre Matysiak, Mairéad Grogan, Mikaël Le Pendu, Martin Alain, Aljosa Smolic

Introduction

Light Fields

Plenoptic function (4D)

$$\Omega \times \Pi \to \mathbb{R}, (x, y, s, t) \to L(x, y, s, t)$$

Sub-Aperture Images

Epipolar Images

Light Fields

Capture Methods

Camera arrays

Single camera on gantry

Plenoptic cameras

2004 - Stanford
Multi-Camera Array
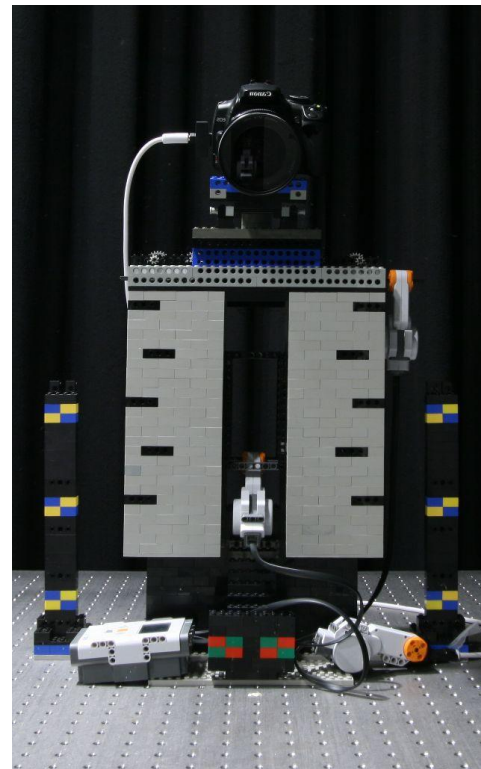
Light Fields

Capture Methods

Camera arrays
Single camera on gantry
Plenoptic cameras

2008 - Stanford
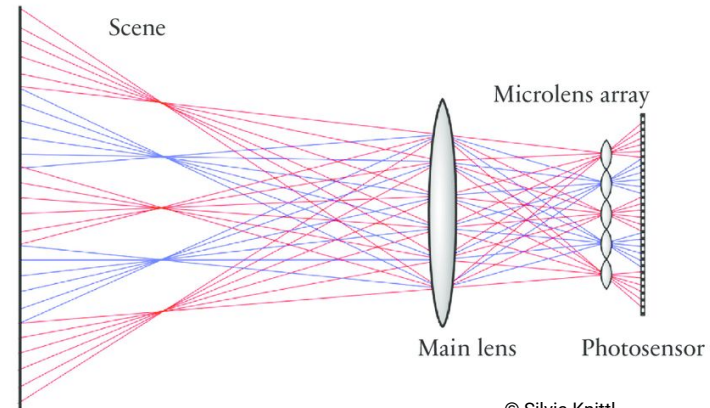Lego Gantry

Light Fields

Capture Methods

Camera arrays

Single camera on gantry

Plenoptic cameras

© Silvia Knittl

Lytro Illum

Motivation

Lytro software unavailable
Does not allow to export
Sub-Aperture Images (SAIs)

Motivation

**Lytro software discontinued
Does not allow to export
Sub-Aperture Images (SAIs)**

Dansereau toolbox limitations :
→ **noise**
→ **ghosting effects**
→ **colour inconsistency**
→ **inaccurate colour balance**
→ **loss of dynamic range**

Colour comparison : Dansereau vs. Lytro

D. G. Dansereau, O. Pizarro, and S. B. Williams, "Decoding, calibration and rectification for lenselet-based plenoptic cameras", in Proc. CVPR, 2013

Motivation

**Lytro software discontinued
Does not allow to export
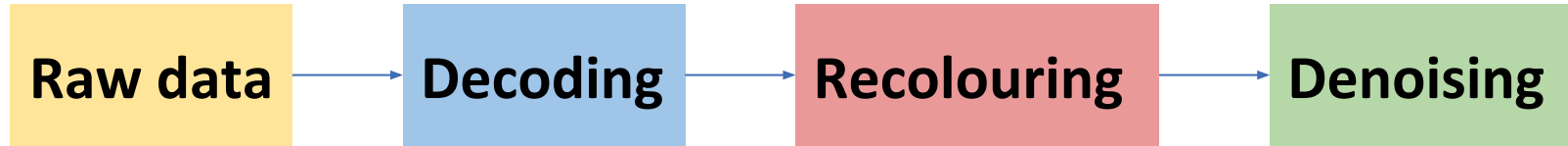Sub-Aperture Images (SAIs)**

Dansereau toolbox limitations

Use all SAIs for applications

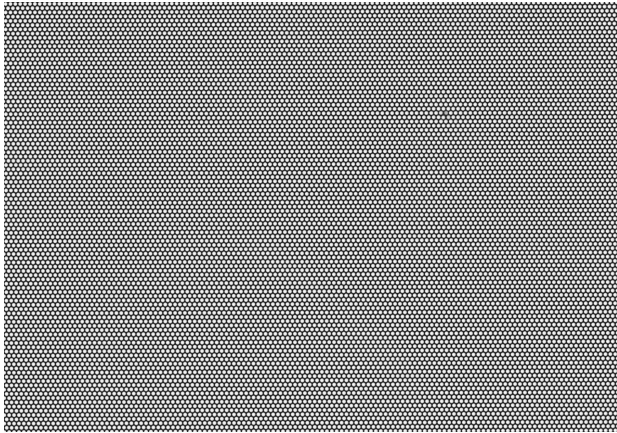Extracted SAIs using Dansereau toolbox

Proposed Pipeline

Raw data → **Decoding** → **Recolouring** → **Denoising**

I. Raw LF Decoding

Devignetting

White Image

Raw Image

After devignetting

I. Raw LF Decoding

Demosaicing + Interpolation

Ghosting effect reduced
Better colour consistency at the cost of noise

Standard demosaicing +
bicubic interpolation

Standard demosaicing +
WI-guided interpolation

WI-guided demosaicing +
WI-guided interpolation

H. S. Malvar, L.-W. He, & R. Cutler, "High-quality linear interpolation for demosaicing of bayer-patterned color images", in Proc. IEEE ICASSP, 2004

P. David, M. Le Pendu, & C. Guillemot, "White lenslet image guided demosaicing for plenoptic cameras", in Proc. IEEE MMSP, 2017

II. Recolouring

Colour Transfer

Target   Palette   Result

M. Grogan and R. Dahyot, "Robust registration of gaussian mixtures for colour transfer",
ArXiv e-prints (May 2017). arXiv:cs.CV/1705.06091

II. Recolouring

CPM

CT needs correspondences
Using first step of Coarse-to-fine Patch Match
Assume centre image has best colours

Y. Hu, R. Song, and Y. Li, "Efficient coarse-to-fine patchmatch for large displacement optical flow", in Proc. CVPR, 2016

II. Recolouring

Propagation scheme

Propagation

II. Recolouring

Propagation scheme

Propagation

II. Recolouring

Propagation scheme

Centre

II. Recolouring

Colour Transfer

Correspondences from centre : best colours
Correspondences from neighbour : consistent colours
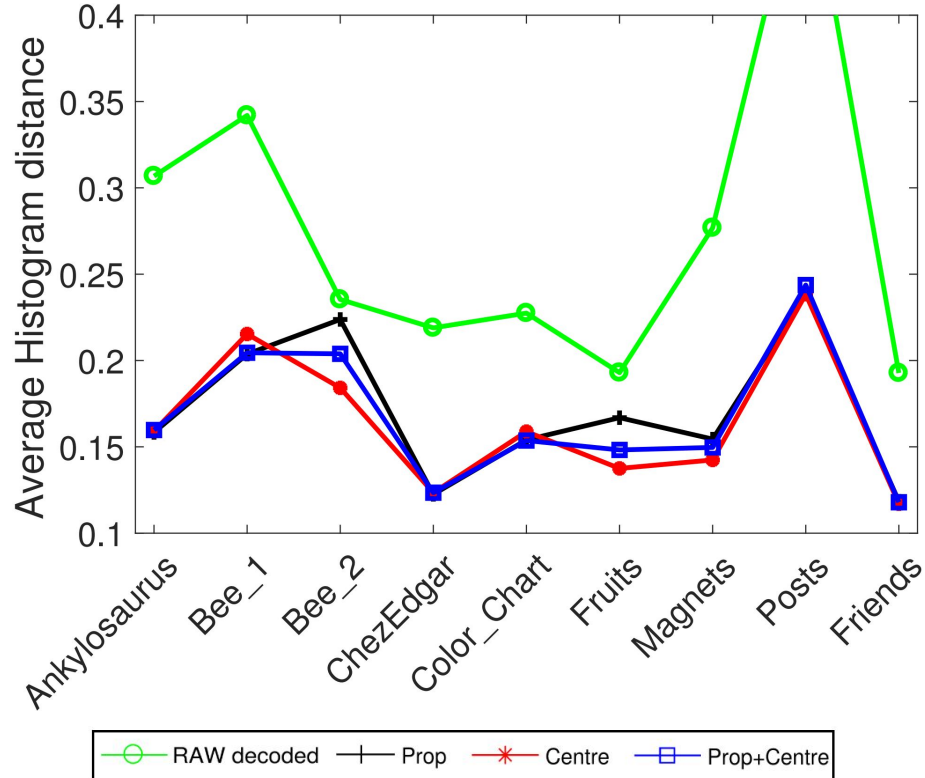

Target
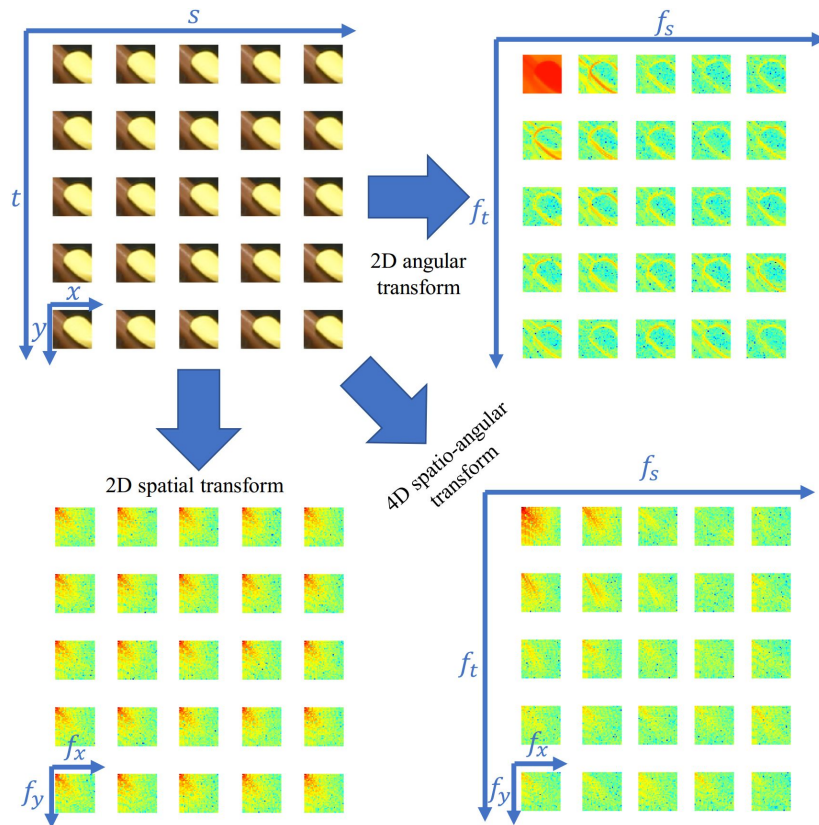(external SAI)

Palette
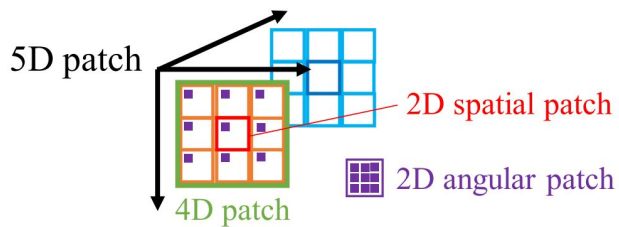(centre SAI)

Result

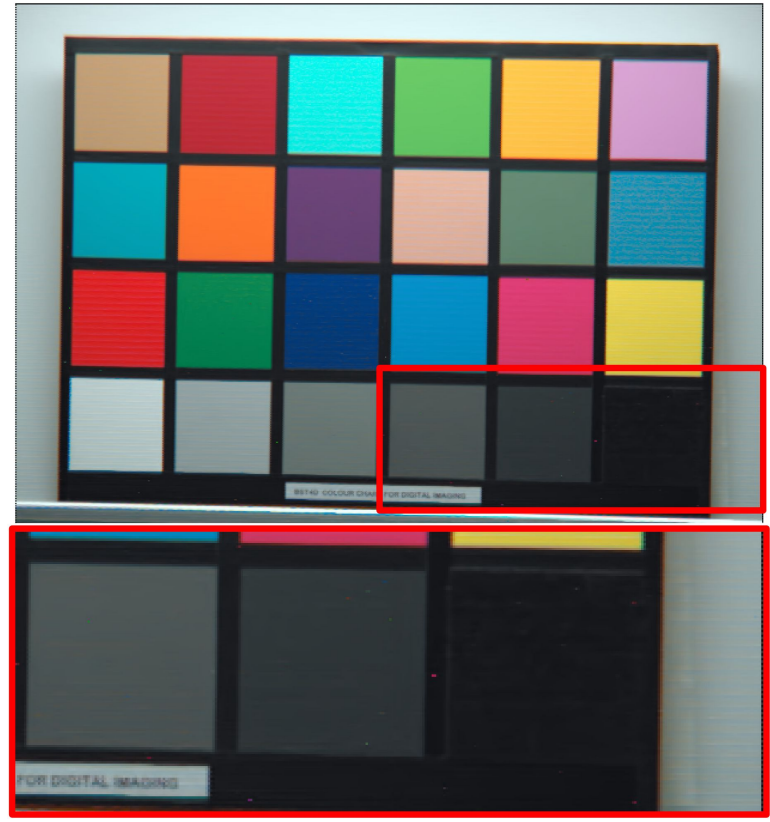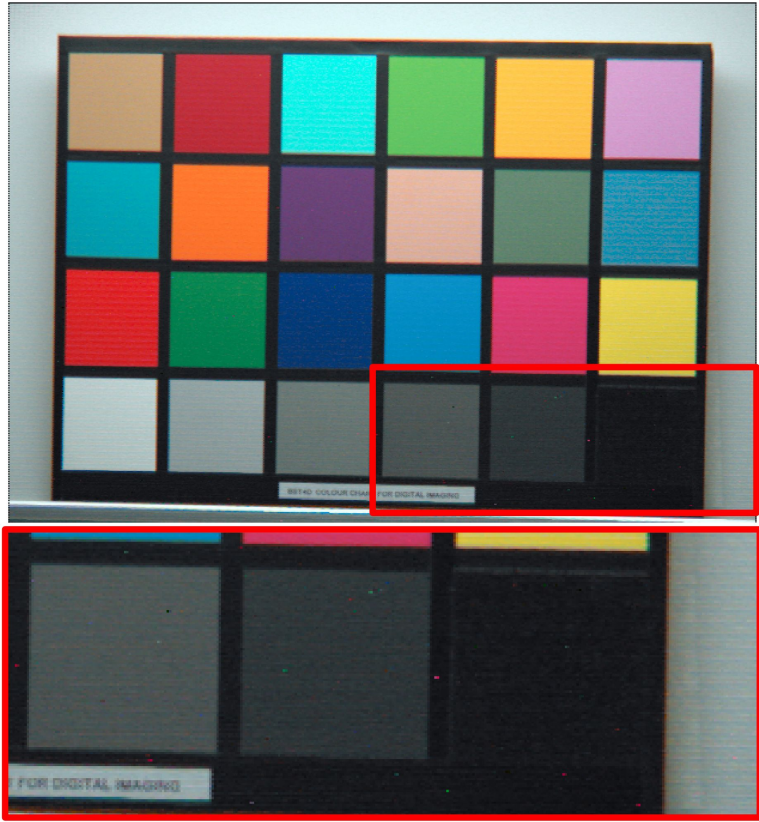# II. Recolouring

Quality metric

III. Denoising

Lytro Illum images are known for exhibiting camera noise

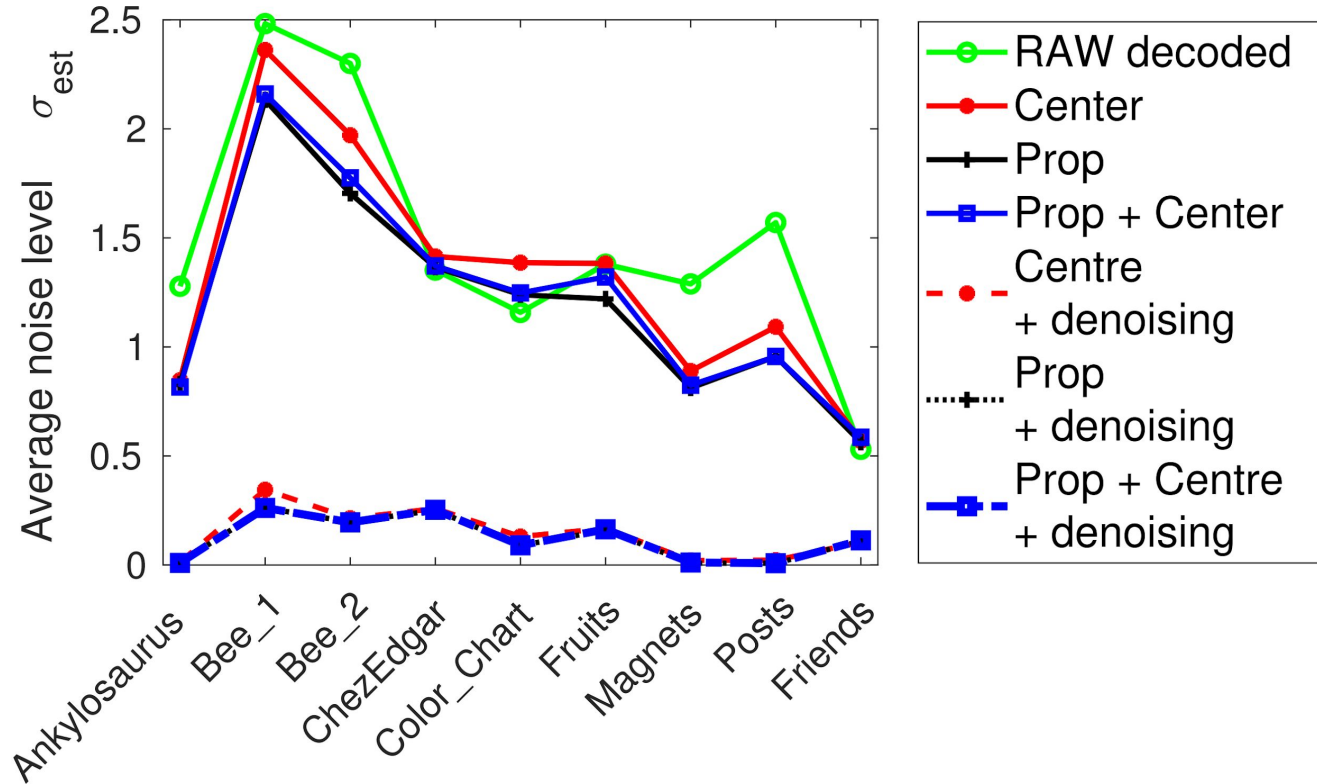**Using SoA LFBM5D filter**

M. Alain and A. Smolic, "Light field denoising by sparse 5D transform domain collaborative filtering", in Proc. IEEE MMSP, Oct. 2017

III. Denoising

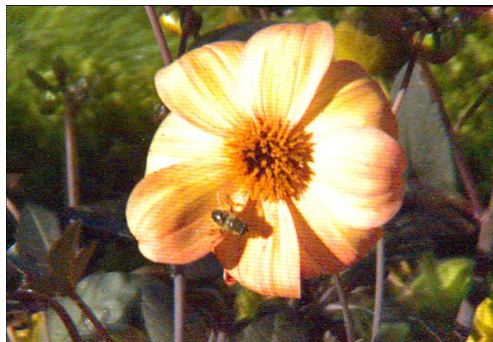# III. Denoising

Quality metric

Results

Single image

External views

Centre views

Dansereau pipeline
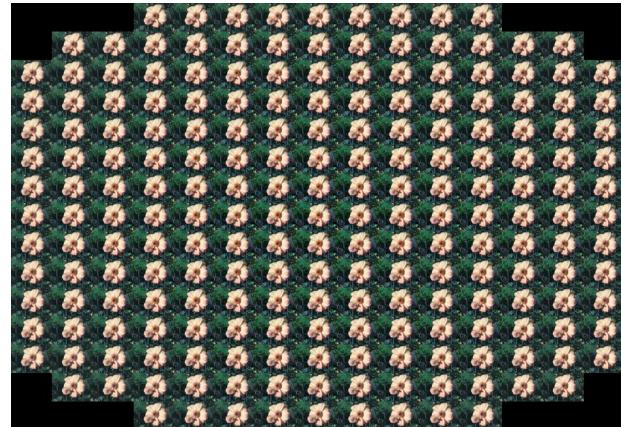
Proposed pipeline

Results

SAI array

Dansereau pipeline   Proposed decoding   Proposed recolouring

Results

Epipolar Images

After decoding   After recolouring   After denoising

Limitations & future work

- **Hot pixel noise**

External SAI

Limitations & future work

- **Hot pixel noise**
- **Ghosting artefacts**

External SAI

Limitations & future work

- **Hot pixel noise**
- **Ghosting artefacts**
- **Lack of good metric for some steps (colour correction)**

Limitations & future work

- **Hot pixel noise**
- **Ghosting artefacts**
- **Lack of good metric for some steps (colour correction)**
- **Long computation time**

Conclusion

- **Full pipeline from RAW**
- **Visual corrections**
- **More information usable**

V-SENSE

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Many Thanks!

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