Christian-Albrechts-Universität zu Kiel

european training network on full parallax imaging

Plenoptic Toolbox 2.0

Benchmarking of Depth Estimation Methods for MLA-based Focused Plenoptic Cameras

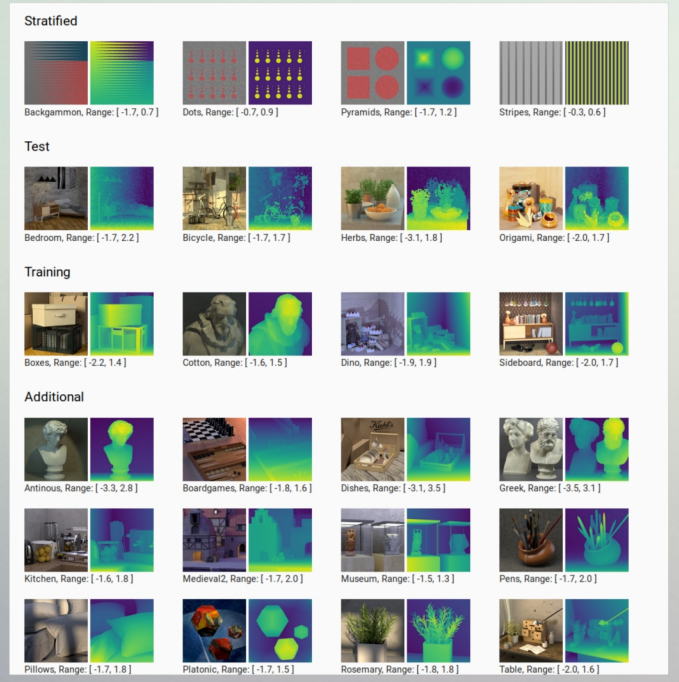
Luca Palmieri, Ron Op Het Veld and Reinhard Koch, CAU Kiel, Germany

Overview of the Presentation

1) Related Work
2) Capturing the Light Field
3) Focused Plenoptic Cameras
4) Aim of the Toolbox
5) Functions of the Toolbox
6) Performance Comparison and Error Analysis
7) Future Work

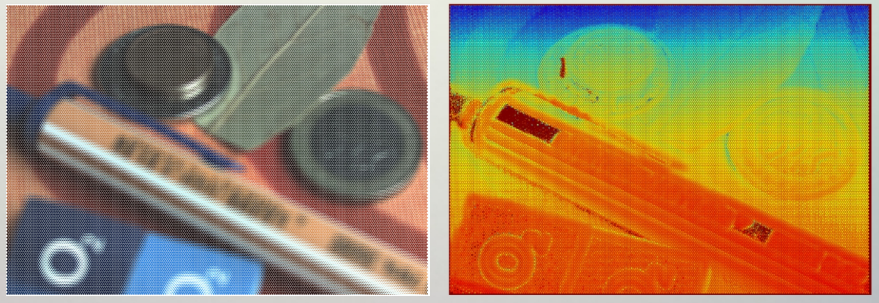
Related Work

There are dataset and toolbox available for general light field images and images acquired with a Lytro camera



Dataset of Light Field synthetic images and benchmark from Heidelberg University [1, 4]

Light Field Toolbox for Lytro Cameras (or light field captured with array of cameras) [6]



No tools and no dataset available for the Raytrix camera or for more general plenoptic 2.0 cameras, few approaches available [2,3]

Capturing the Light Field

Array of Cameras – Stanford implementation

Plenoptic Camera – Raytrix R29 [5]

Plenoptic Cameras

Lytro Camera

Lytro Illum

Plenoptic 1.0

►Higher angular resolution
►Lower spatial resolution

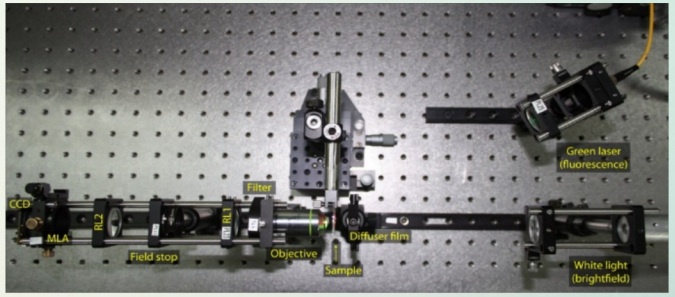
Raytrix Camera

Raytrix R29 [5]

Plenoptic 2.0 or Focused Plenoptic Camera

►Lower angular resolution
►Higher spatial resolution
►Extended depth-of-field

FiMic Microscope



Fourier Integral Microscope [8]

Custom Setup

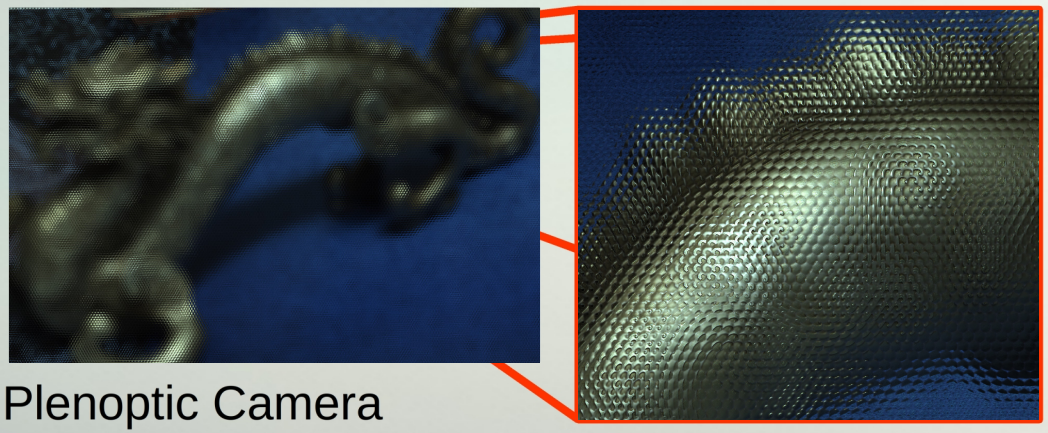
►Raw Images contains the Elemental Images
►Higher parallax between views

Focused Plenoptic Camera

Plenoptic Camera

Conventional Camera

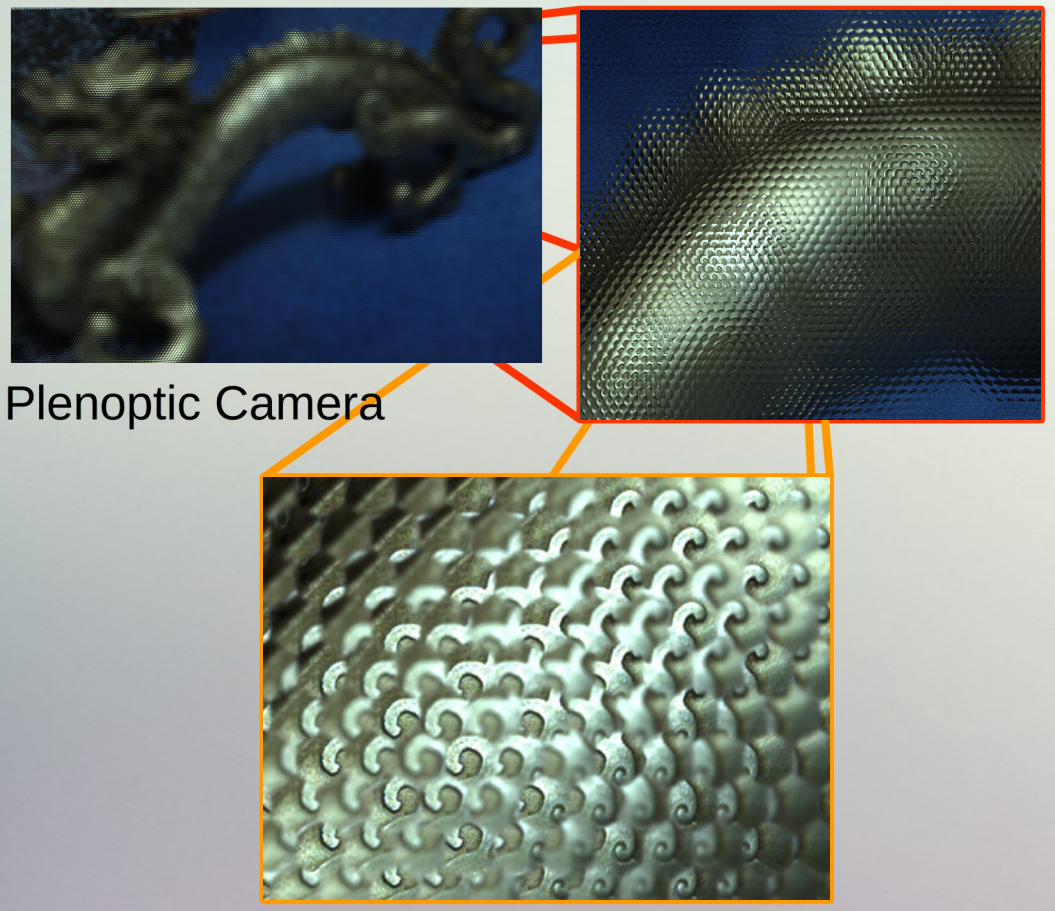
Focused Plenoptic Camera



Plenoptic Camera

Conventional Camera

Focused Plenoptic Camera



Plenoptic Camera

Conventional Camera

Aim of the Toolbox

- Push the research in the direction

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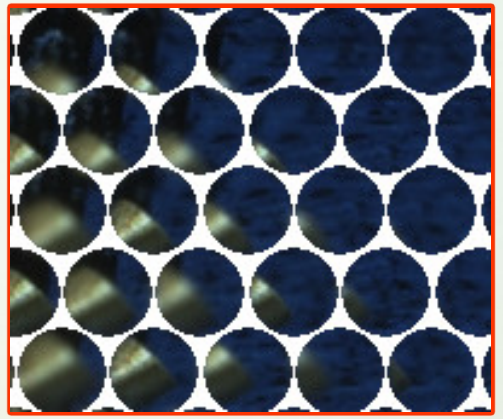
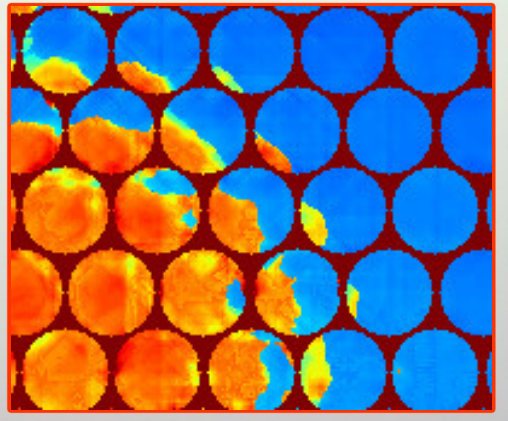
- Push the research in the direction
- Create a dataset of images from different setup of plenoptic cameras
- Open source code implementation of different methods (implemented in Python)
- Provide synthetic images and ground truth for objective and numerical analysis

Plenoptic Toolbox 2.0

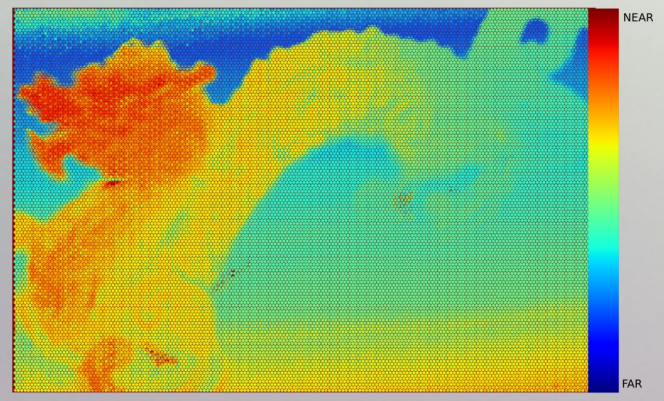
Processed Image as input



Multi view stereo matching

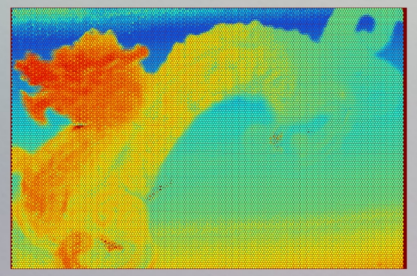


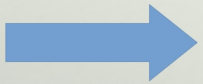
Disparity map per each lens

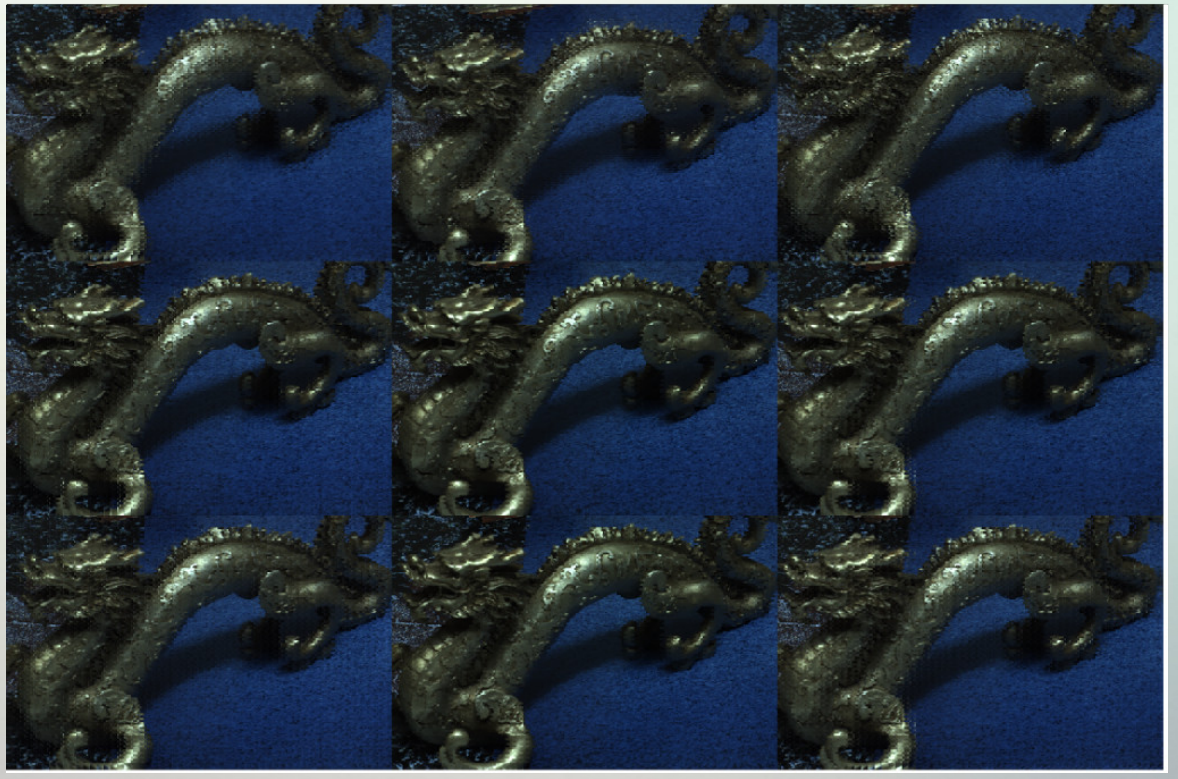


Final disparity image

Refocusing and Perspective



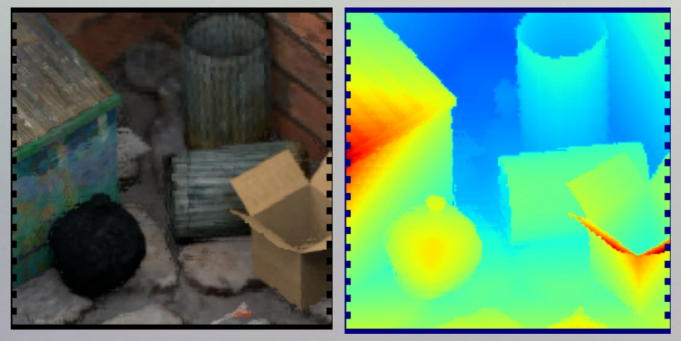
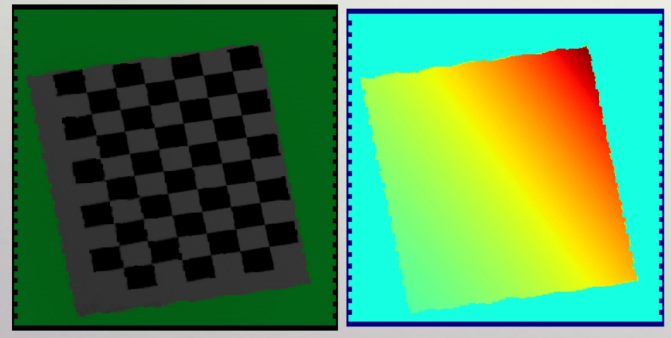
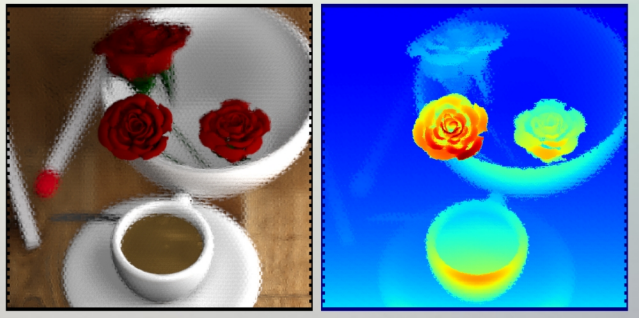




By combining the colored image and the disparity information we can obtain a refocused version or perspective views, as usual in the plenoptic 1.0 camera

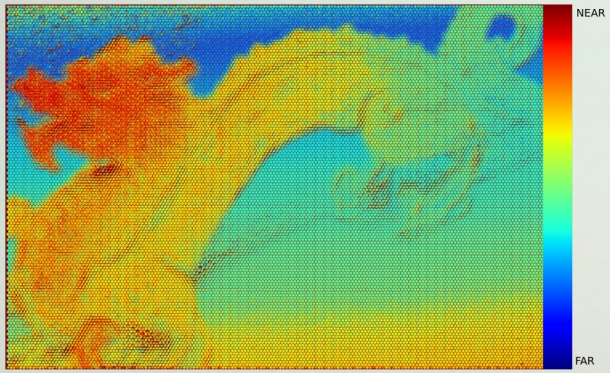
What kind of images are available?



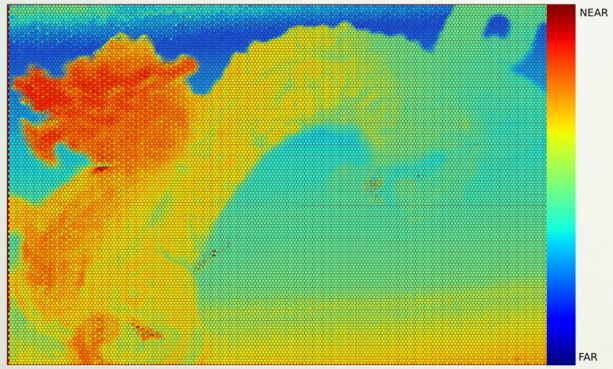




The dataset contains both real and synthetic images. The scenes were chosen to be take into account different aspects as texture, colorfulness, depth structure, specularities and so on.

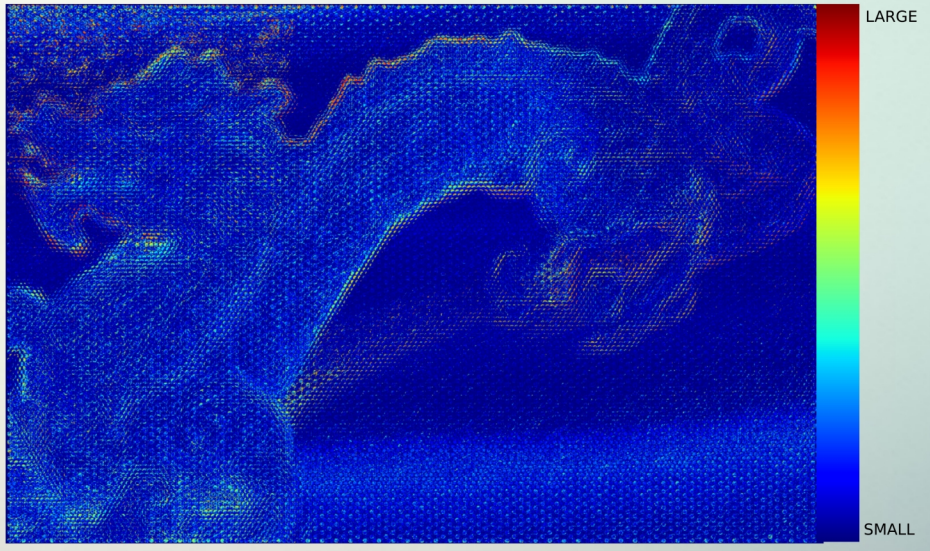
What can we do with it?



Stereo Matching using
CENSUS Transform



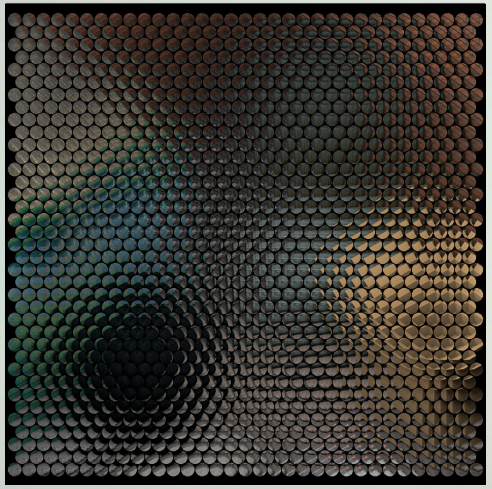
Stereo Matching using
Sum of Absolute Distance



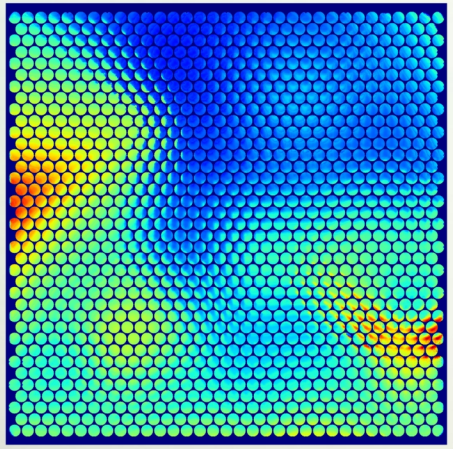
Difference image – around edges the two images show large differences

If we do not have a ground truth image, the evaluation remains subjective!

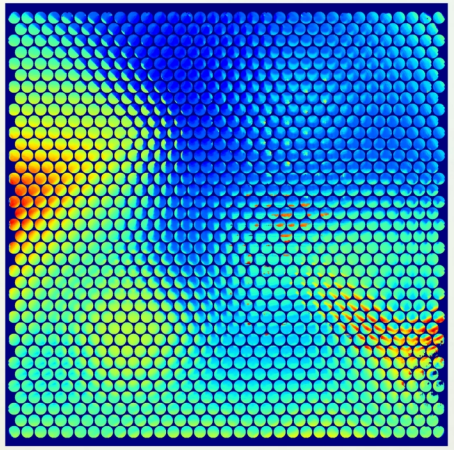
Synthetic Images



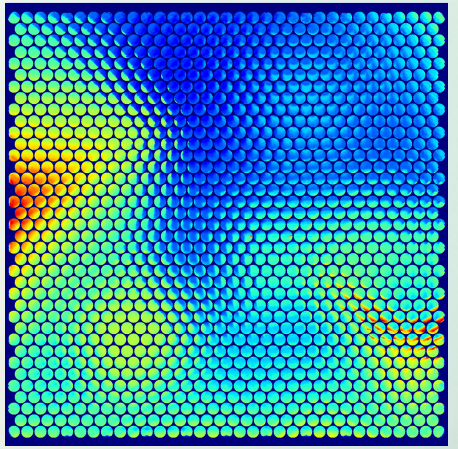
Synthetic Image



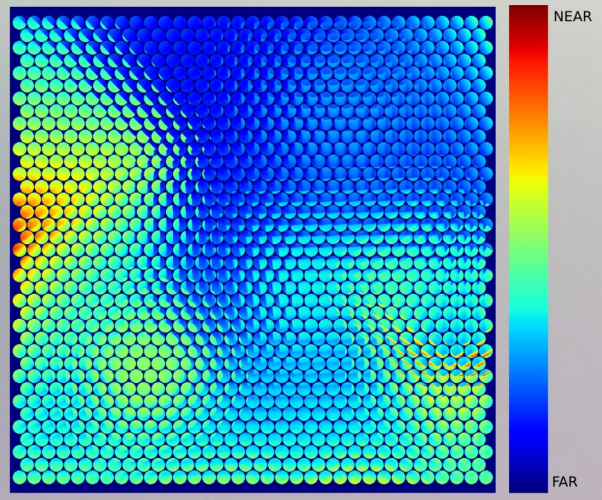
SM with Absolute Difference



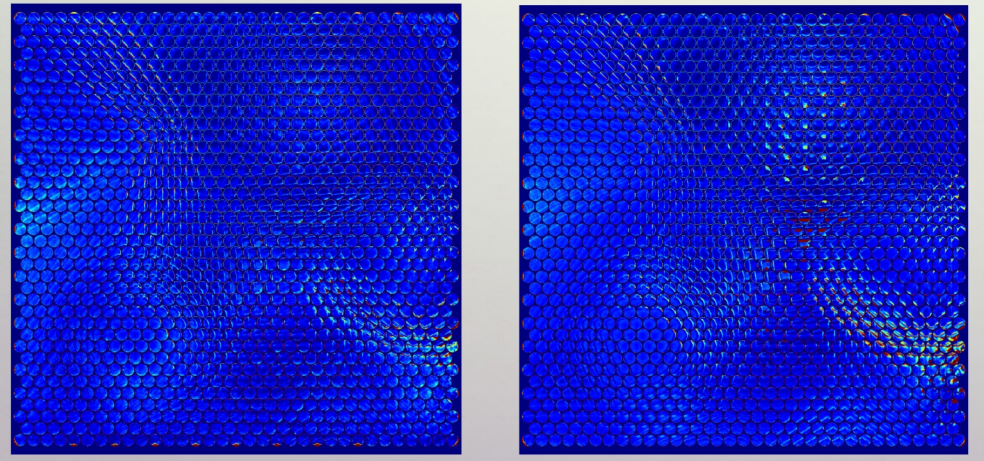
SM with Normalized Cross Correlation



SM with Gradient



Ground Truth



Difference image against the ground truth (red indicates higher error)

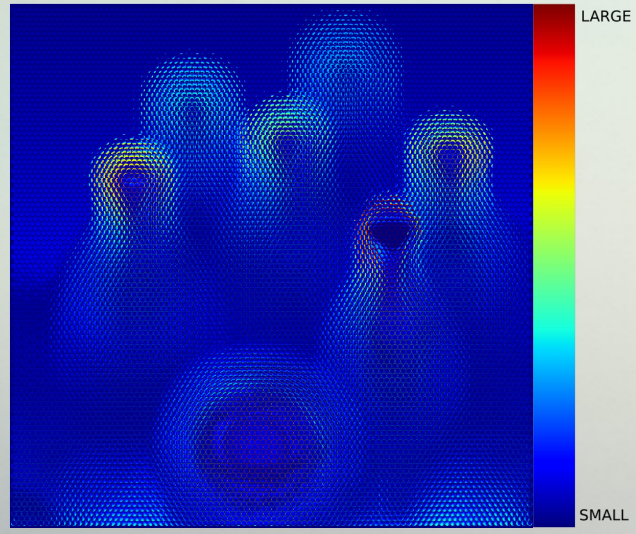
Performance Comparisons

- Not many approaches available
- Most used similarity measures used in the stereo matching literature [7]

Absolute Difference (AD)	Squared Difference (SD)	Normalized Cross Correlation (NCC)	CENSUS Transform	Gradient transform (GRAD)

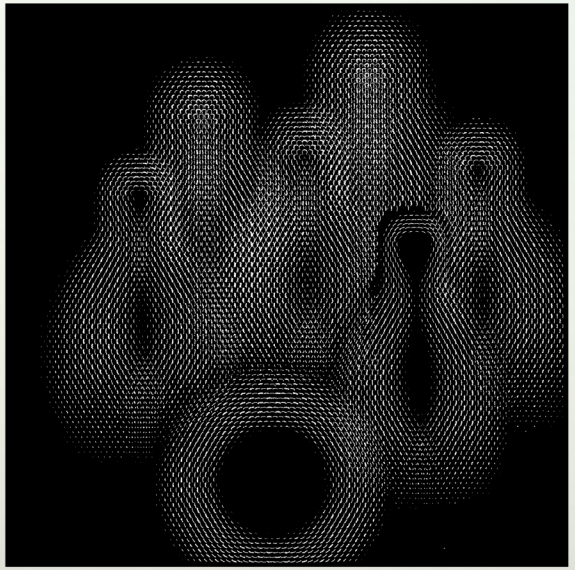
Different Error Measurements

Bad Pixels Error Maps



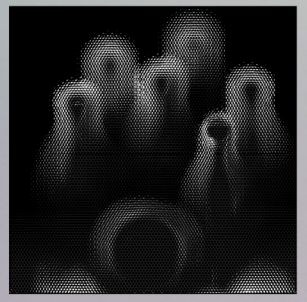
Error map Proposed approach against Ground Truth

Depth Discontinuities

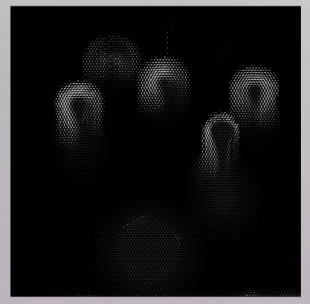


Pixels labeled as belonging to depth discontinuities

Pixels labeled as belonging to areas with smooth depth

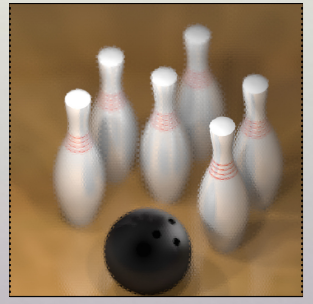


Bad Pixels 1 Error Map



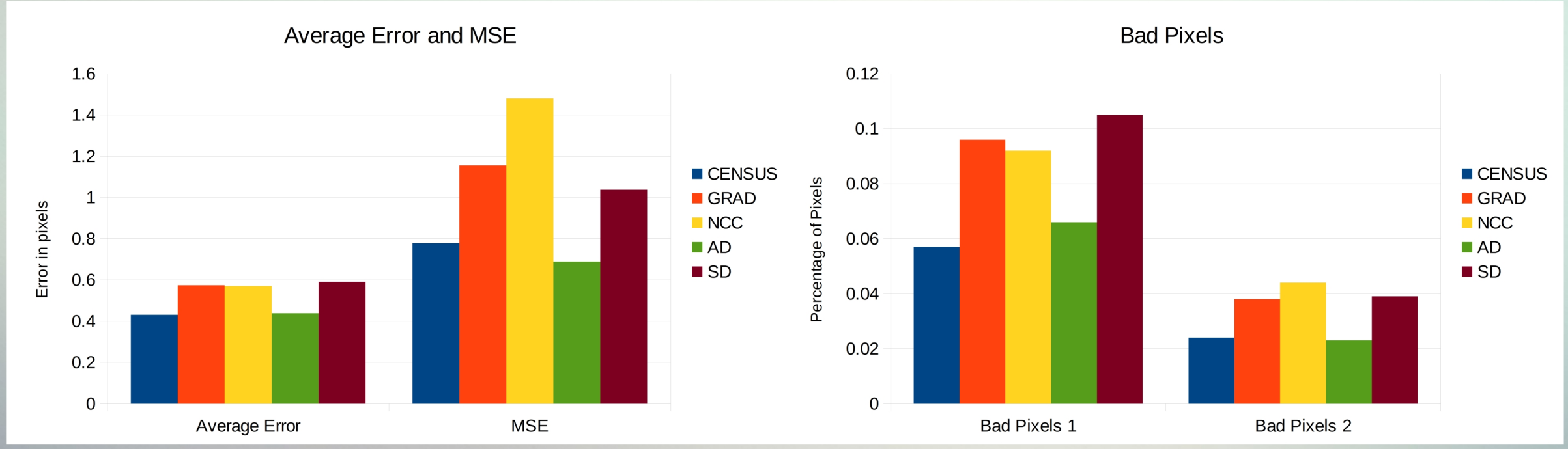
Bad Pixels 2 Error Map

White labeled pixels denote errors larger than X pixel (X = 1,2)



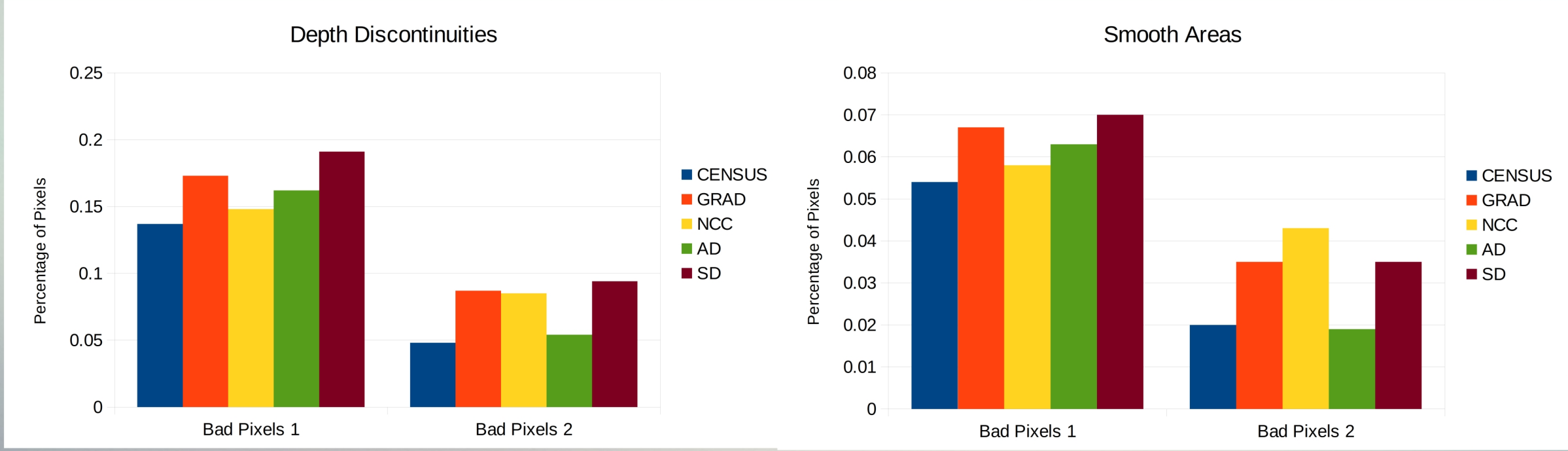
The actual color image as a reference

Error Analysis



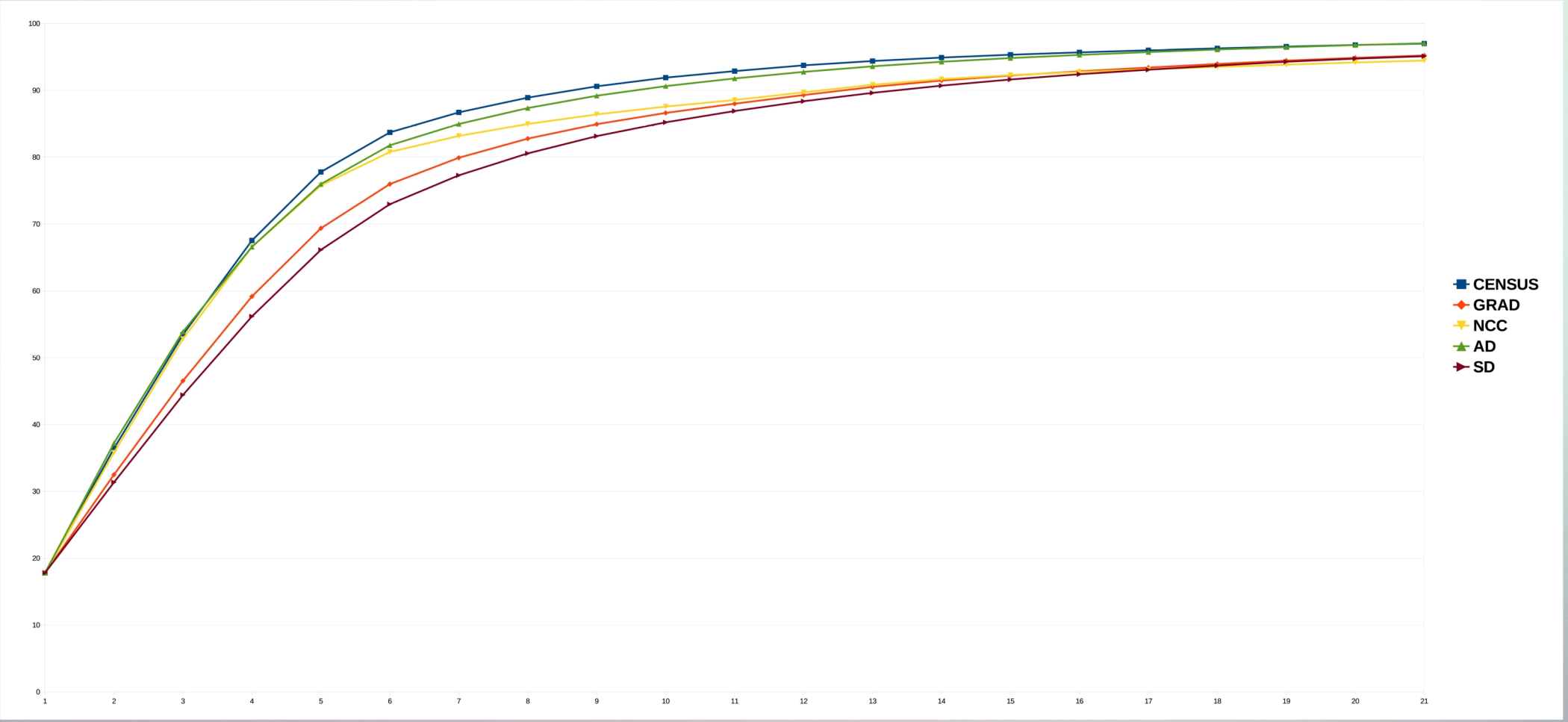
The error analysis gives us a further insight on the measures. Average error and MSE gives a general score, while the bad pixels results explains the distribution of the errors based on their size.

Error Analysis



Using the depth discontinuities map, a deeper analysis can be made, obtaining a spatial distribution of the errors and how they deal with smooth areas.

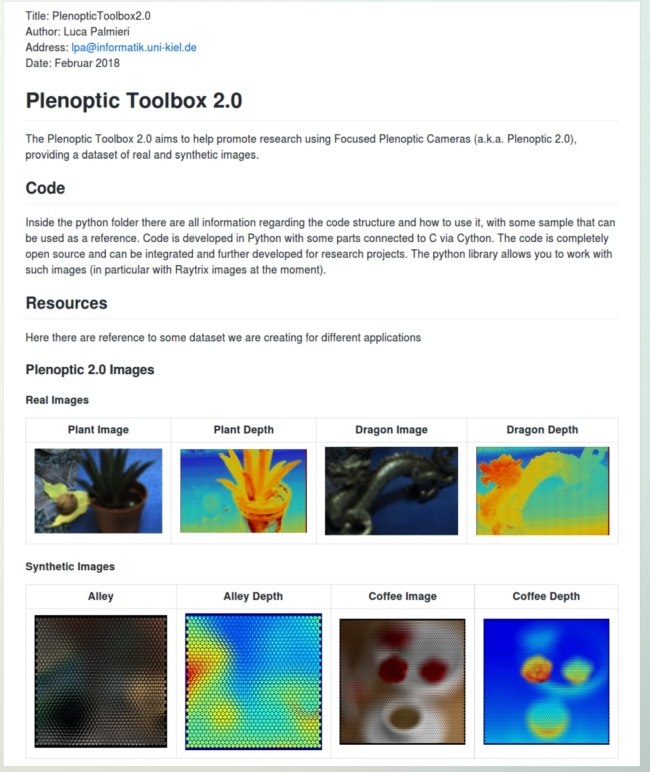
Error Analysis



A further insight in the error distribution is given in this graph. We can see how three methods (CENSUS, AD and NCC) perform very good for low error, but then only two of them (CENSUS and AD) keep their performance for larger error.

Conclusions

- New tools for handling Plenoptic 2.0 Images (open source *python* code)
- New datasets consisting in images suitable for different applications
- Analysis of different measure similarities through insight in the errors type



Title: PlenopticToolbox2.0
Author: Luca Palmieri
Address: lpa@informatik.uni-kiel.de
Date: Februar 2018

Plenoptic Toolbox 2.0

The Plenoptic Toolbox 2.0 aims to help promote research using Focused Plenoptic Cameras (a.k.a. Plenoptic 2.0), providing a dataset of real and synthetic images.

Code

Inside the python folder there are all information regarding the code structure and how to use it, with some sample that can be used as a reference. Code is developed in Python with some parts connected to C via Cython. The code is completely open source and can be integrated and further developed for research projects. The python library allows you to work with such images (in particular with Raytrix images at the moment).

Resources

Here there are reference to some dataset we are creating for different applications

Plenoptic 2.0 Images

Real Images

Plant Image	Plant Depth	Dragon Image	Dragon Depth

Synthetic Images

Alley	Alley Depth	Coffee Image	Coffee Depth

Open Source Code and Images available at:

https://github.com/PlenopticToolbox/PlenopticToolbox2.0

Future Work

- Test different disparity estimation methods
- Handle dynamic scenes and motion
- Create benchmark with training and test images

References

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Acknowledgements

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