
TU WIEN

CVL Computer Vision Lab

# Error correction in Multispectral Imaging

## A blackbox approach

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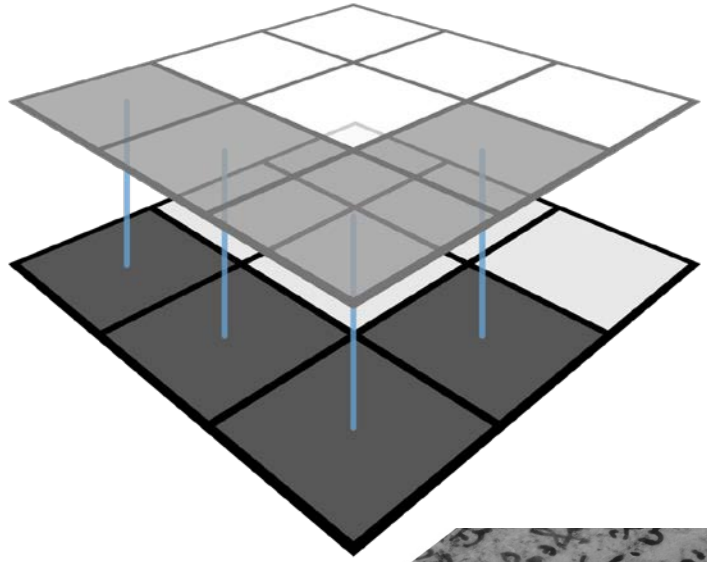
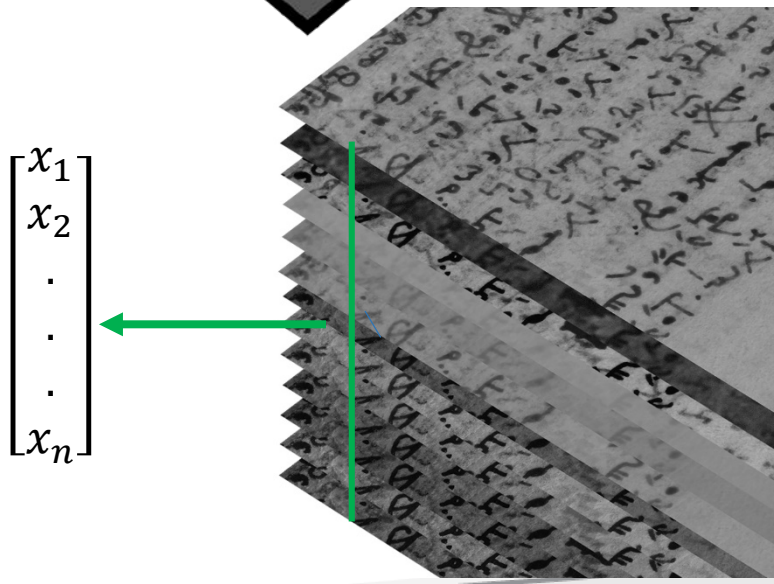
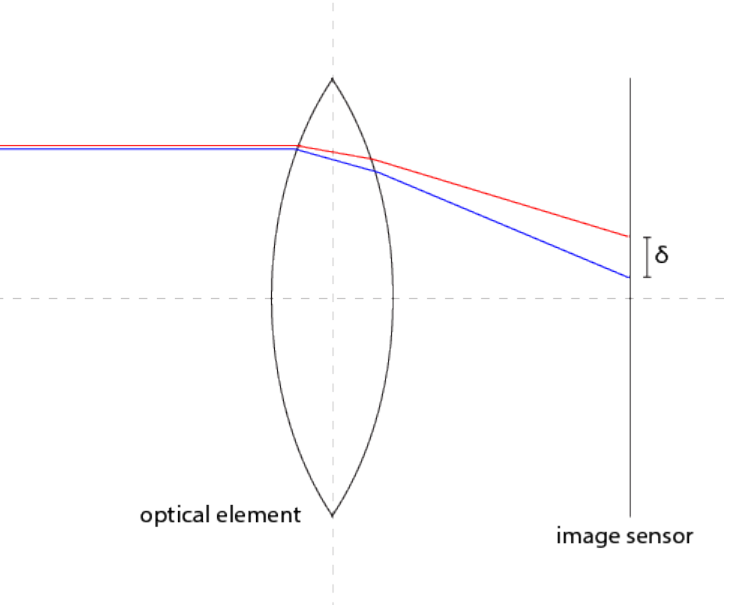
# Motivation

- What we want from our images:
  - Pixel-accurate alignment
  - Focus
- Why?
  - Precondition for postprocessing:
  - „Spectral signature“ for each point
    - Statistical methods (PCA, ICA, etc.)
    - Machine learning
  - Visualization
    - Linear combinations
    - Pseudocolor images
    - …

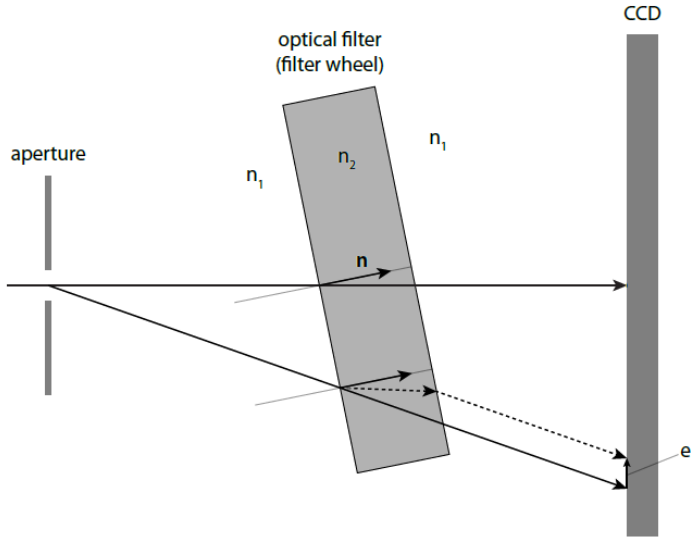




# Reality




Chromatic aberrations:
Misalignments **& focus shift**!



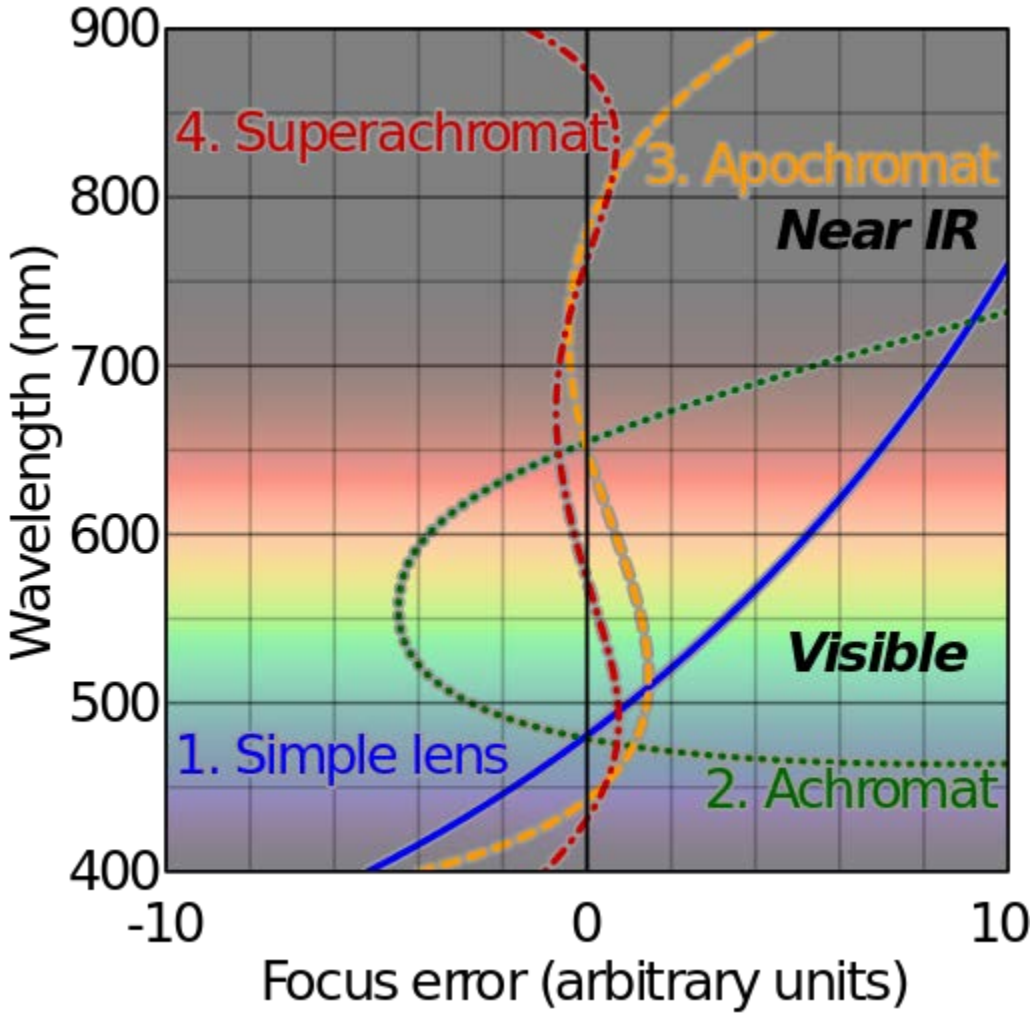

Changing filters

Deforming parchment (humidity, temperature)

unnoticed impacts

# Part 1: Focus correction

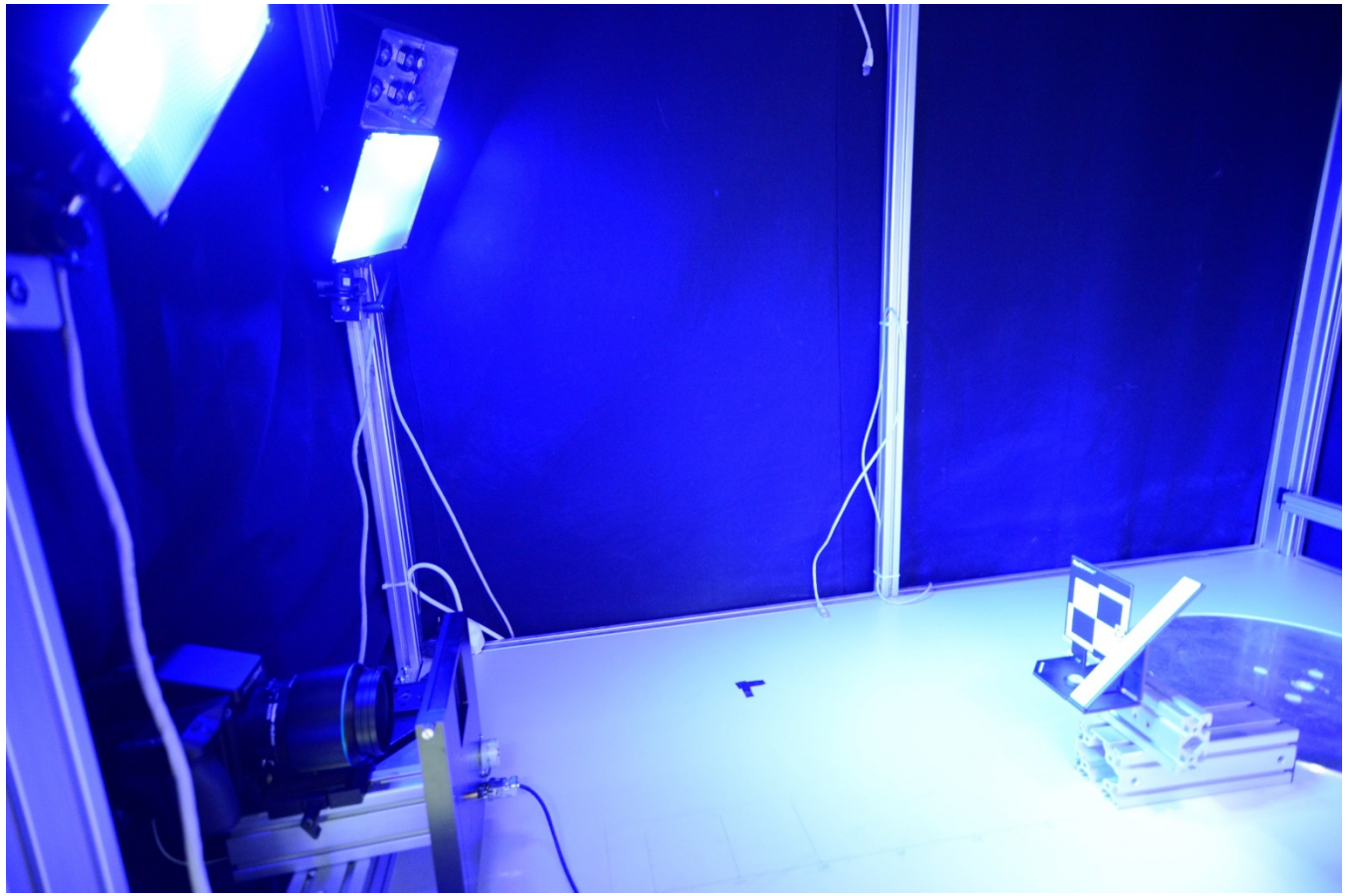
- Refraction angle is wavelength-dependent
  - → Focal plane is wavelength-dependent!
- **Conventional lenses** optimized for visible spectrum → focus shifts are neglible there
- But: unfeasible focus shifts in IR and UV spectra
- Cannot be corrected in post-processing!



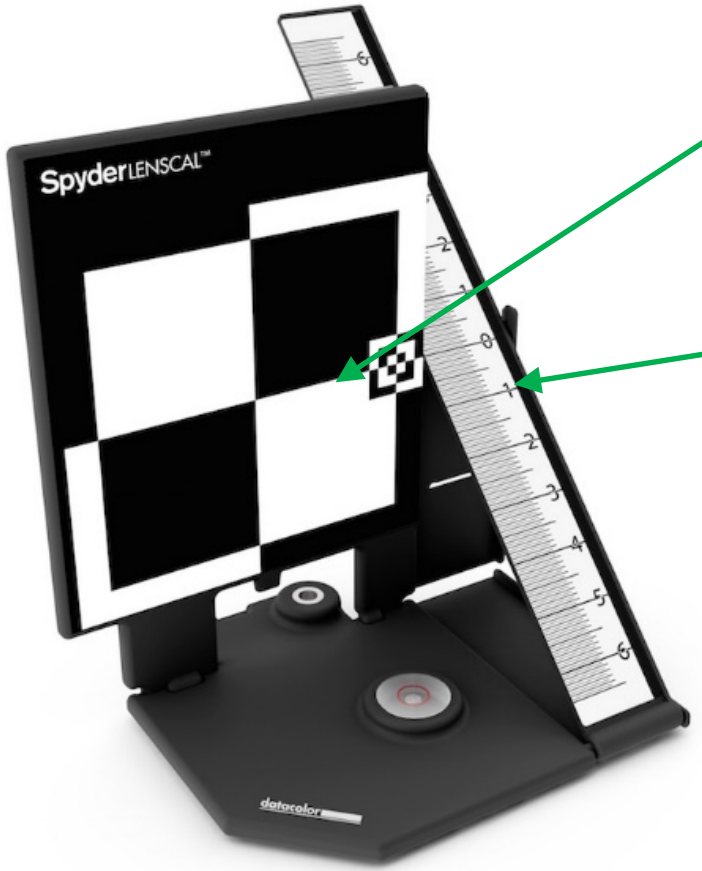

https://en.wikipedia.org/wiki/Superachromat#/media/File:Comparison_chromatic_focus_shift_plots.svg

# Possible Solutions

- A: Buy specialized lens
- B: Correct the focus shift
  - Calibrate your lens
  - Auto-correct focal plane depending on wavelength and distance



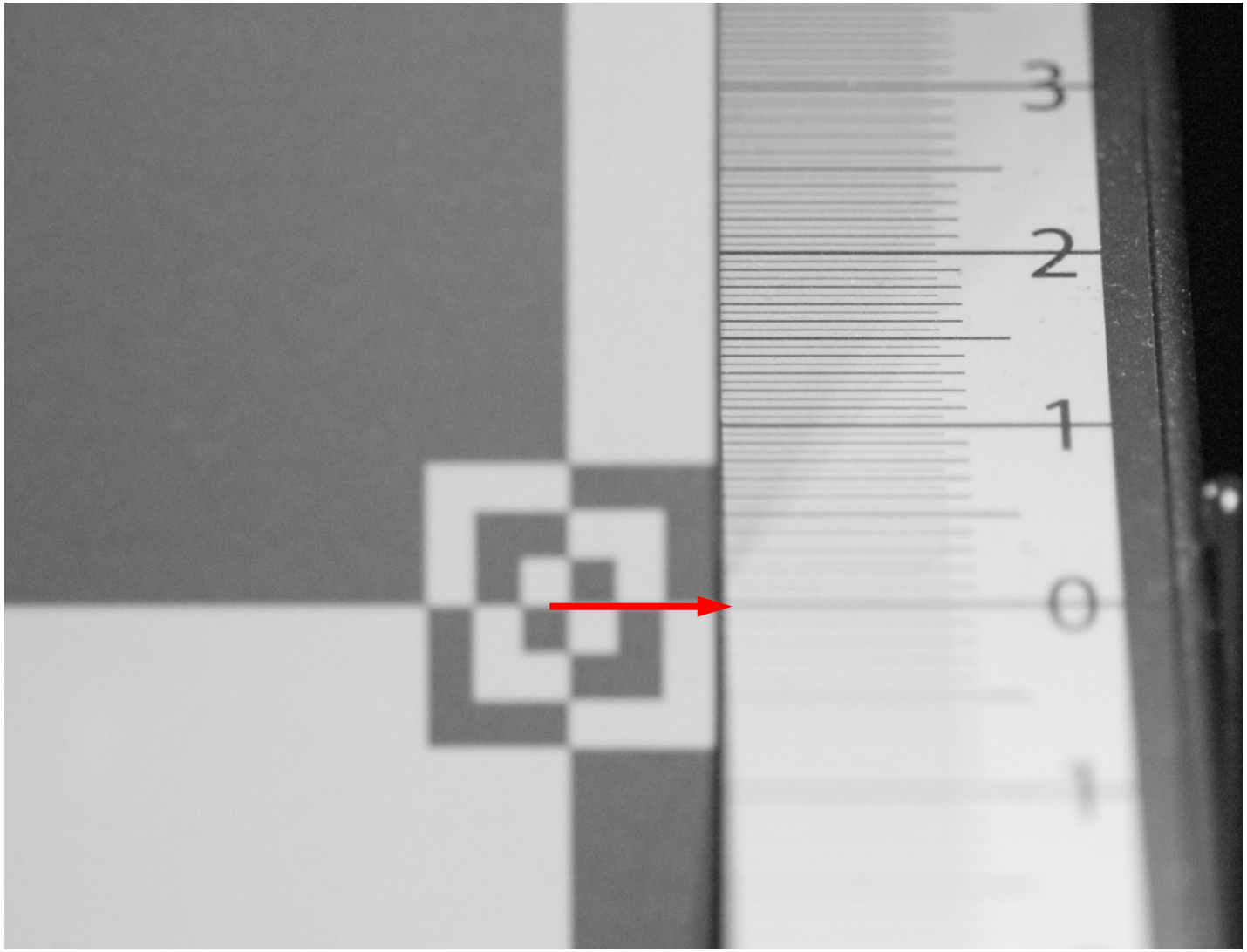
# Calibration procedure

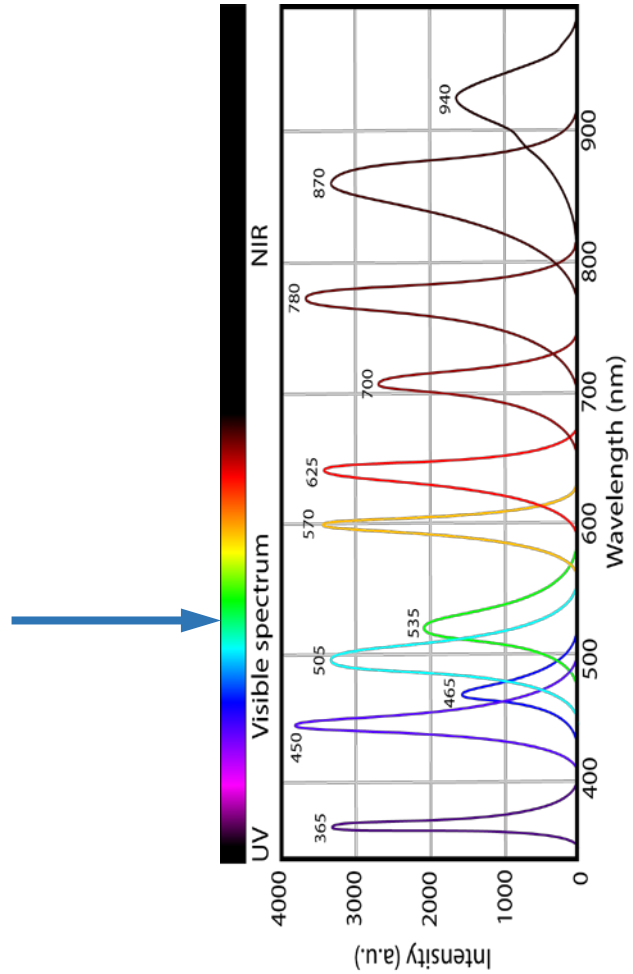



Autofocus calibration device

1. Focus on plane under *visible light*
2. For each *invisible wavelength*
   take picture
   read focus offset on scale

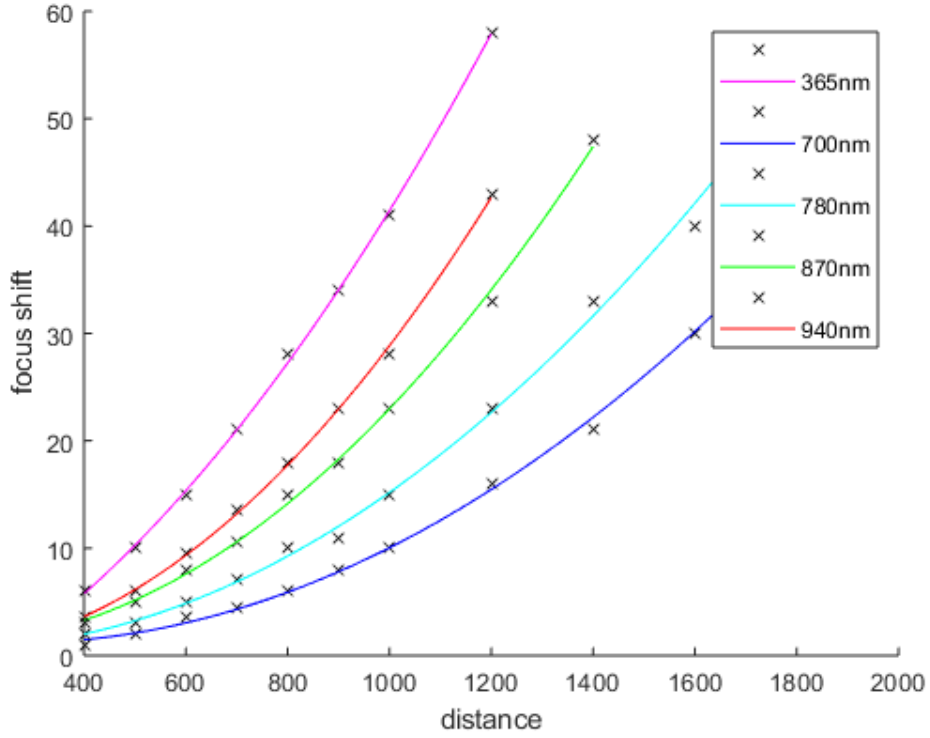
# Example (Lens: Schneider Kreuznach 120mm ls f/4.0 Macro)

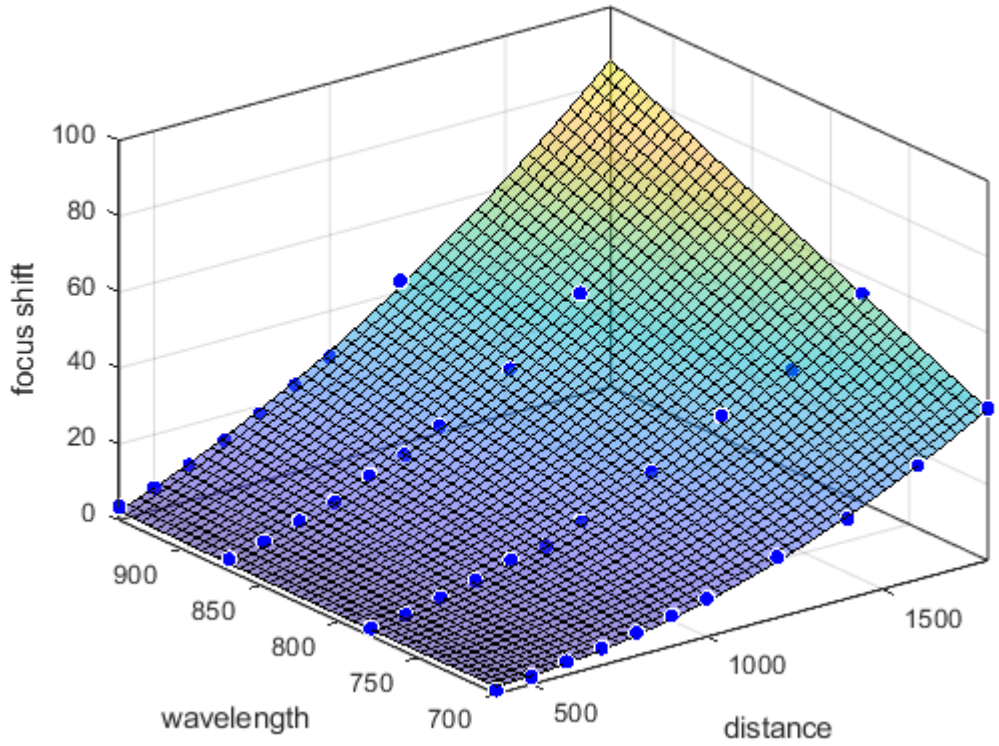


# Fit a function

- Repeat for several distances covering your typical working range
- Fit a function



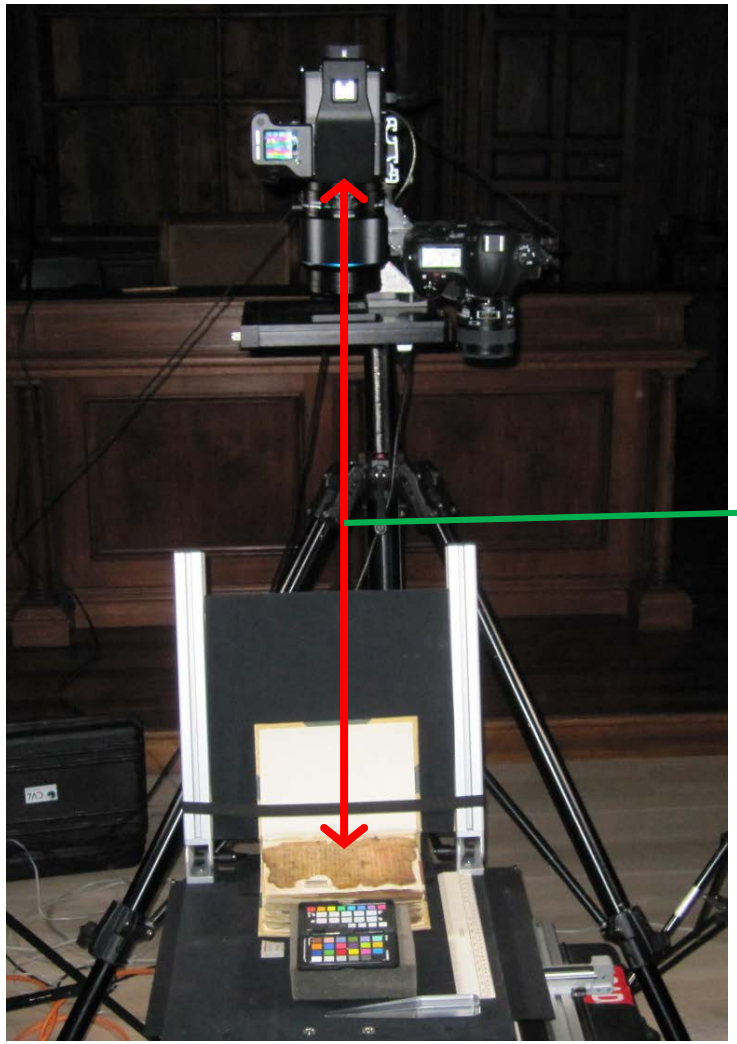



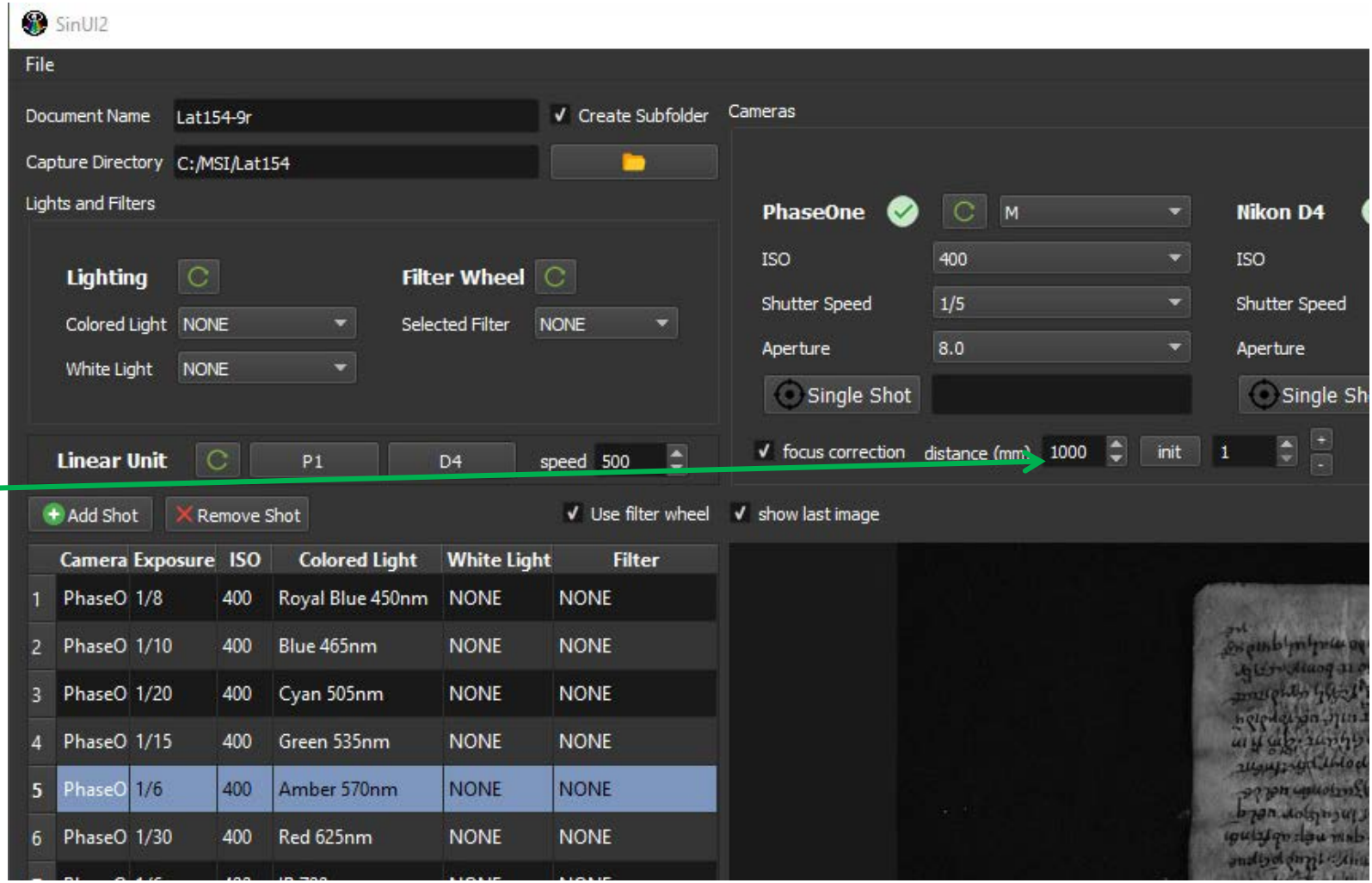
# Adjust focus

## a) Drive autofocus motor

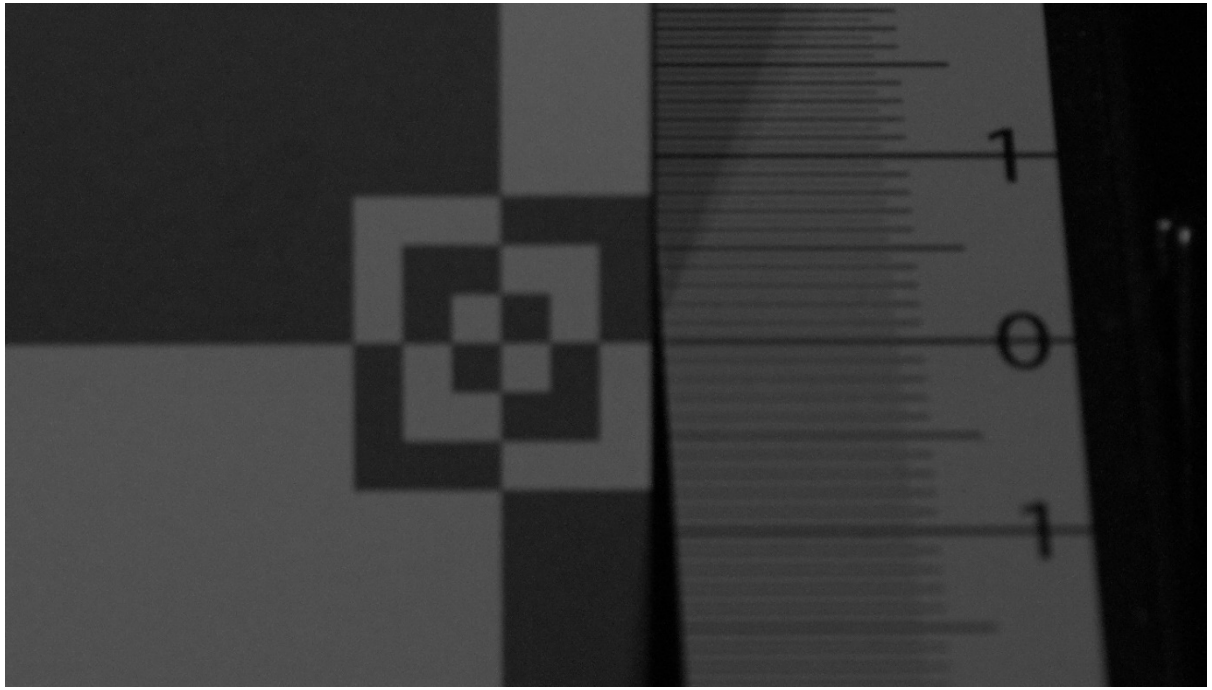

## b) Adjust working distance (linear unit)

# Adjust focus

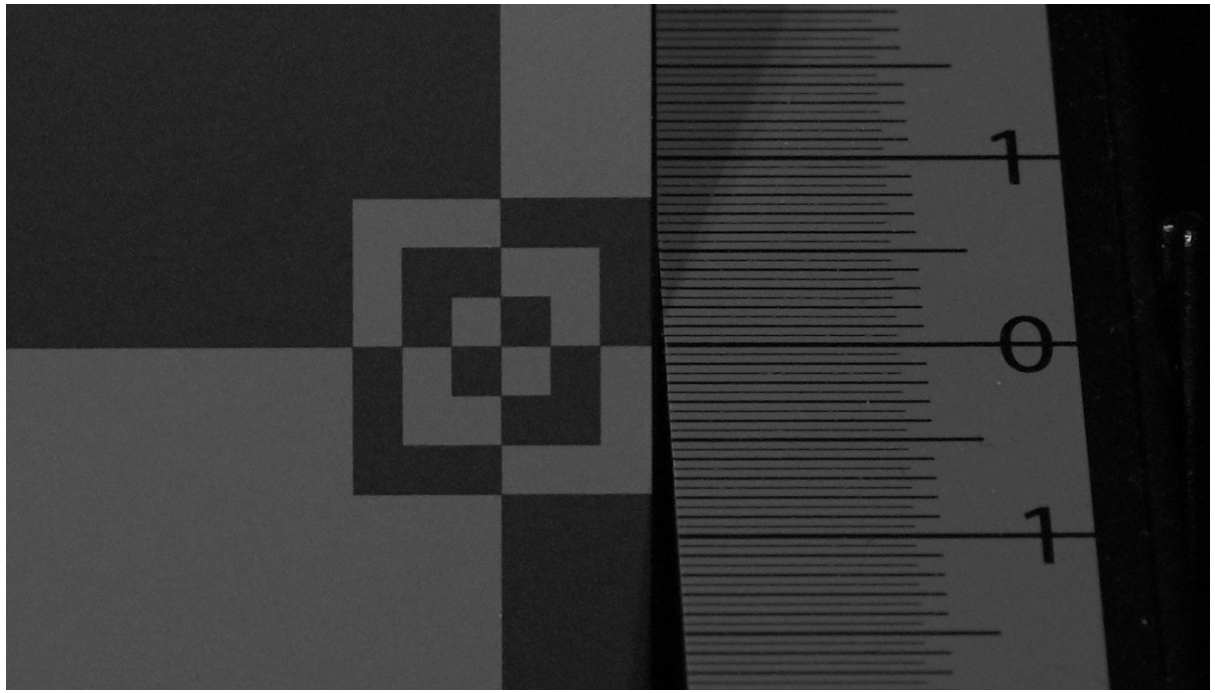




# Example: 1m distance, f8, 365nm (UV)




No correction




Proposed correction method

# Conclusion

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- Can be used if specialized lens is not available / feasible / out of budget
- No knowledge about lens elements required → BLACKBOX

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- Calibration a bit time consuming
- Adaptions to acquisition software required
- Introduces new source of misalignments

# Part 2: Correcting misalignments

- Misalignment is a composition of different factors
  - Chromatic aberration
  - Changing filters
  - **Focus correction**
  - Unnoticed mechanical impacts
  - **Deforming parchment**

predictable

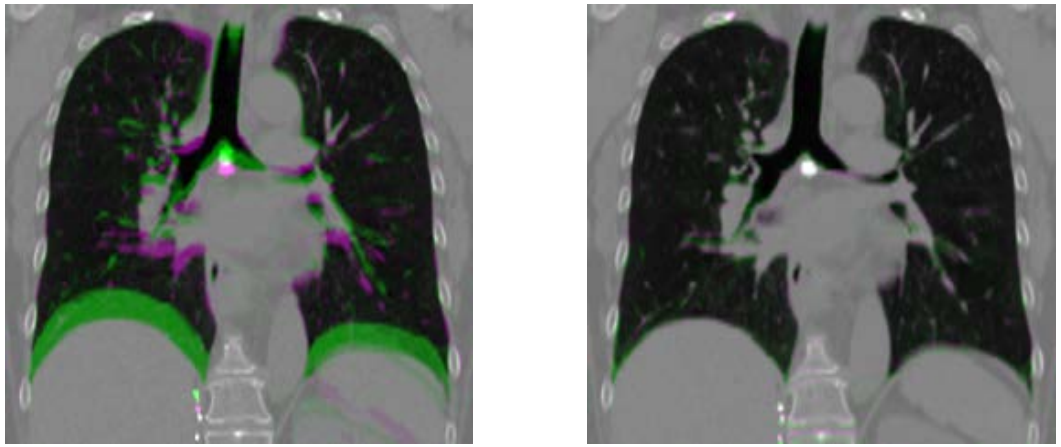
affine

deformable

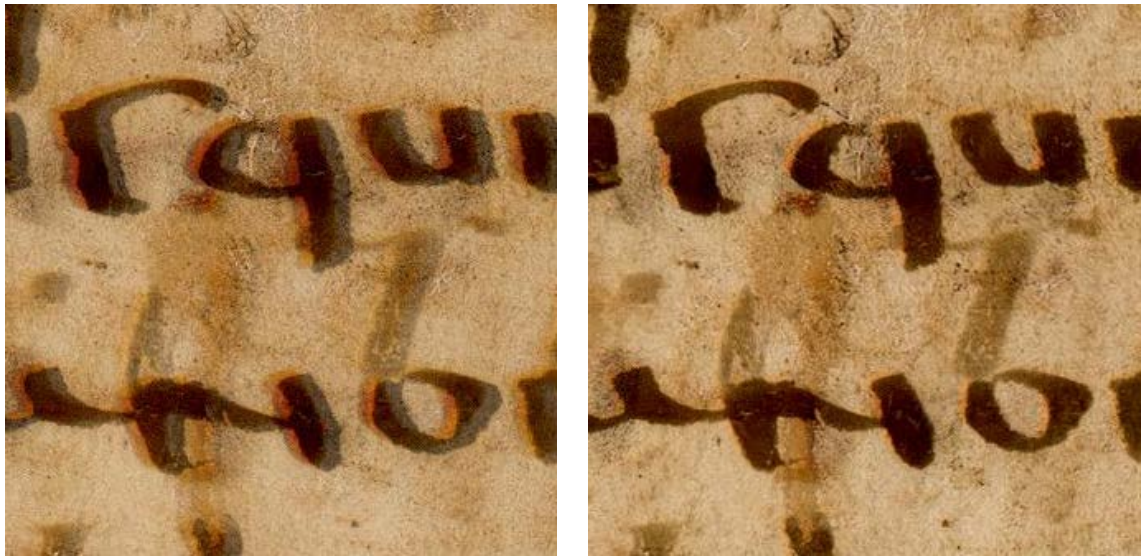
- Correction by calibration possible
- Misalignments can be corrected with affine transformations
- Deformable non-parametric registration (displacement field): cover all classes of misalignments

# Excursion: Medical Image Registration

- **Highly active research area with similar problems**
  - Different imaging modalities (CT, MRI,..)
  - Arbitrary deformations of organs between shots



Registration of CT and MRI scan [1]

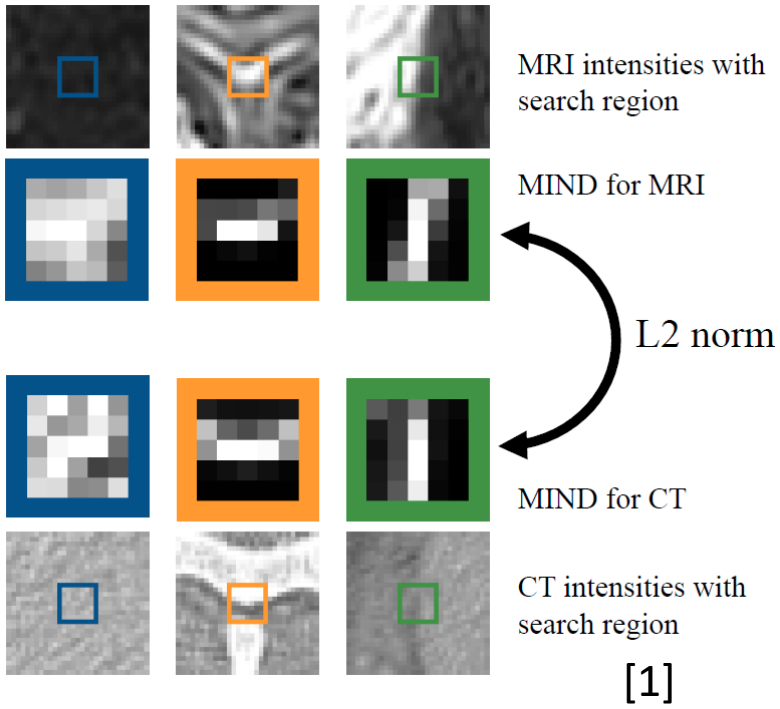


Registration of two manuscript images

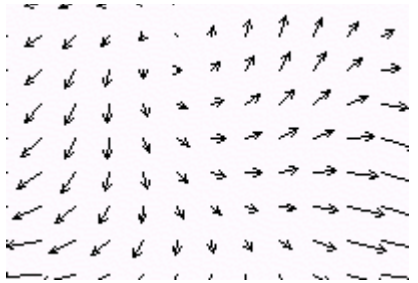
[1] M. P. Heinrich, M. Jenkinson, M. Bhushan, T. Matin, F. V. Gleeson, S. M. Brady, and J. A. Schnabel, “Mind: Modality independent neighbourhood descriptor for multi-modal deformable registration,” Medical Image Analysis, vol. 16, no. 7, pp. 1423–1435, 2012.

# Deformable registration: outline

- Densely compute local image descriptors
  - E.g.: „MIND: Modality Independent Neighbourhood Descriptor for Multi-Modal Deformable Registration [1]”
  - Based on self-similarity
- Define error metric
  - E.g. L2-Norm
- Optimize deformation field
  - Minimize errors (e.g. Gauss-Newton optimization)
  - Regularization terms for plausible solution (e.g. diffusion)




[1]



Deformation field

[1] M. P. Heinrich, M. Jenkinson, M. Bhushan, T. Matin, F. V. Gleeson, S. M. Brady, and J. A. Schnabel, “Mind: Modality independent neighbourhood descriptor for multi-modal deformable registration,” Medical Image Analysis, vol. 16, no. 7, pp. 1423–1435, 2012.

# Conclusion

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- Treats all kinds of misalignments
- Don‘t need to care about source of disalignments → BLACKBOX
- Delivers pixel accuracy

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- Time consuming




# Thank you