Camera Array for Multispectral Imaging

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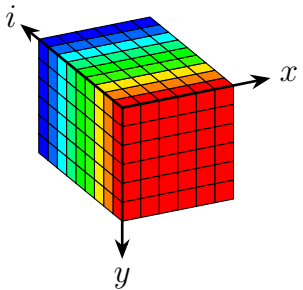
Multispectral Imaging

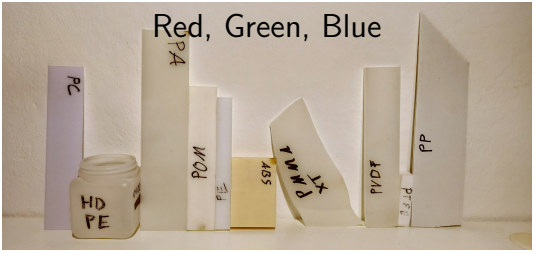


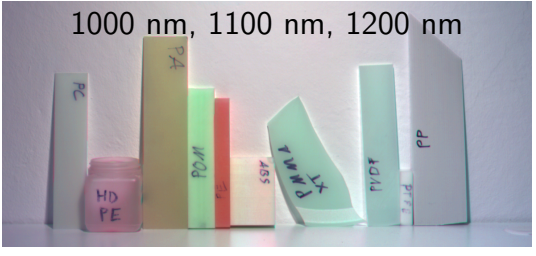
Camera Array for Multispectral Imaging (CAMSI)

- Multispectral imaging: record six to 16 different channels
- How to unfold the multispectral datacube?
- CAMSI: Record each channel by a separate camera
- Advantage: Snapshot capabilities $\rightarrow$ Multispectral videos

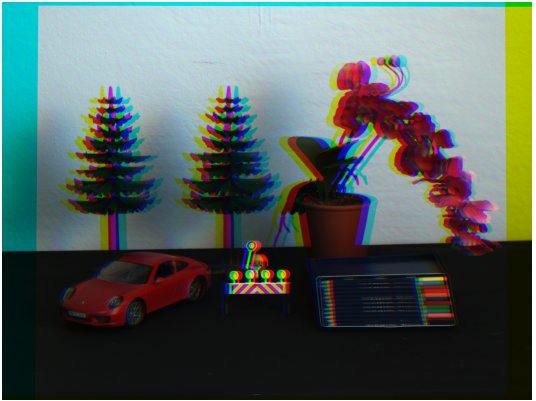
Multispectral Imaging

- Applications:
- Material classification
- Agriculture
- Forensics
- Medicine
- Chemical engineering





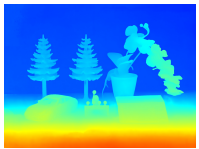
CAMSI Problem



Problem

Different cameras record scene under different angles

CAMSI Problem



Disparity estimation

Image warp

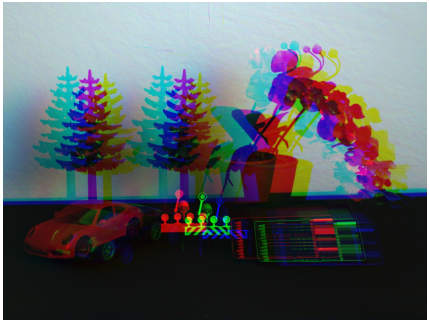
Reconstruction

- Cross-spectral disparity estimation
- Disparity used to warp images to center view
- Peripheral cameras capture slightly different angles → Occluded pixels occur → Reconstruction process necessary

Calibration

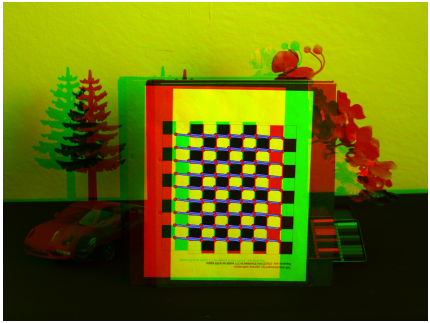
Problem

- Problem: Different camera views are not aligned at all



- Camera not perfectly arranged within camera array
- Manufacturing deviations
- Position of sensor in cameras not always exactly the same
- Lenses may vary slightly
- Filters have an optical influence
- First step: Calibration

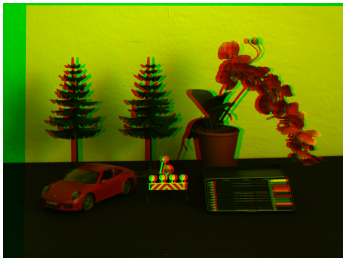
Calibration



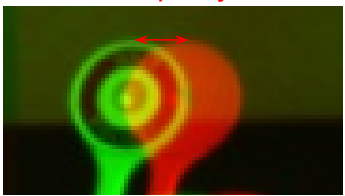
- Calibration process necessary to align cameras
- Use of checkerboard pattern to find calibration matrix
- Ensure epipolar constraint $\rightarrow$Only search on horizontal line for disparities

Cross-spectral disparity estimation

- Goal: Find corresponding pixels between two views
- Disparity estimation $\rightarrow$ Find distance between pixels of two views
- Usually, classic stereo matching for RGB views
- Here, two grayscale images in different areas of the light spectrum
- Cross-spectral disparity estimation
- Possible to recover actual depth from disparity

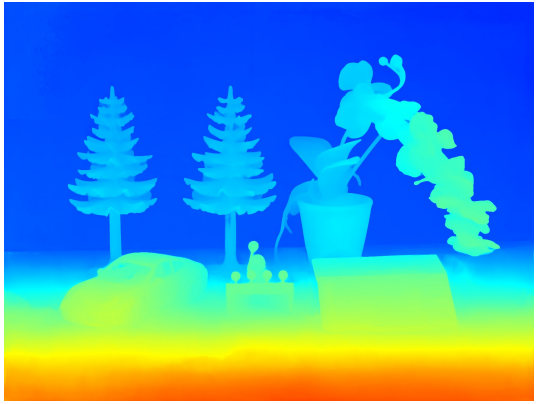


Disparity



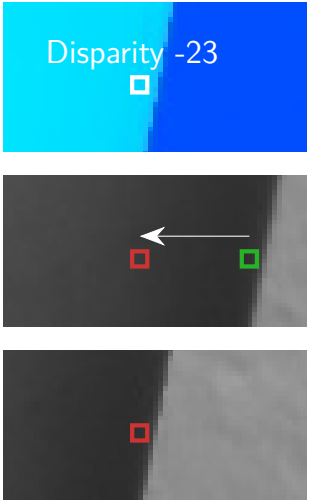
Cross-spectral disparity estimation

- Classical and neural network-based approaches possible
- Views in different areas of the light spectrum
- Usually some kind of normalization employed
- For example, for a classic pipeline, compare two patches using zero mean normalized cross-correlation
- Negative and positive correlation good



Warping

- Task: Use disparity map to warp pixels of peripheral camera to center view
- Idea: Disparity directly shows, which position in the peripheral view corresponds to which pixel in the center view



Warping

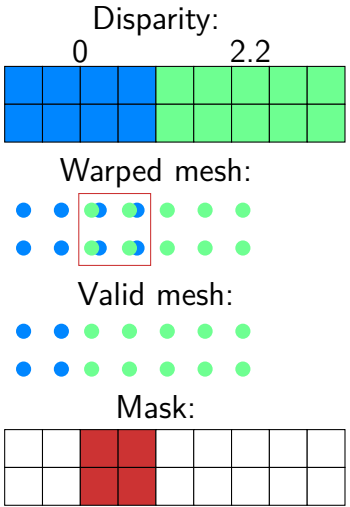
Problem

- Direct warping does not work for occluded areas
- Occluding objects are warped to the background

- When does it happen?
- Blue (background) has a smaller disparity than turquoise (foreground)
- Pulls same pixels on edges

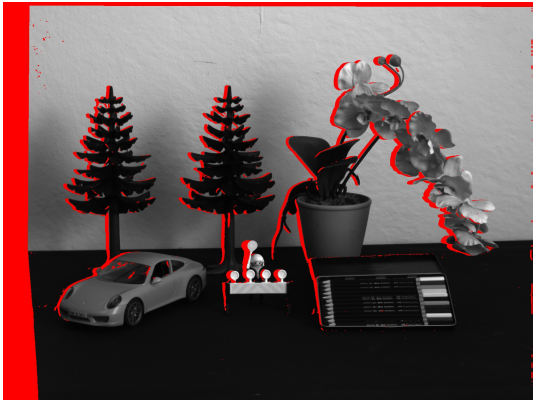
Warping

- Warp disparity to peripheral view and evaluate warped mesh
- Get distance to nearest neighbors
- Warped point valid if
  - Nearest neighbor bigger than threshold distance (e.g. 0.7)
  - Mesh point has biggest disparity within all neighbors with distance smaller than threshold distance
- Biggest disparity $\rightarrow$ closest to camera $\rightarrow$ foreground



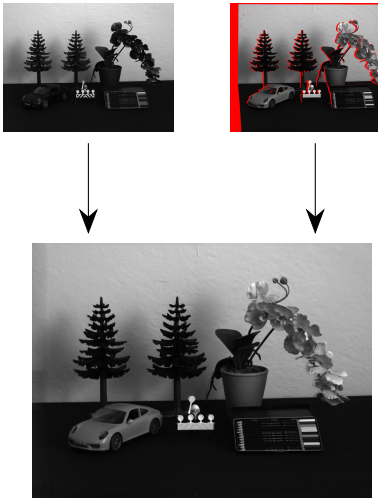
Warping

- Applied to whole image
- Pixels on the border masked since outside of original image
- Missing pixels need to be reconstructed

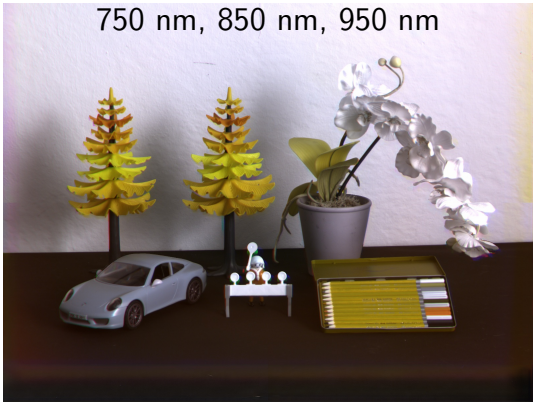


Cross-spectral reconstruction

- Reconstruction of occluded pixels necessary
- No pure inpainting problem since cross-spectral references are available
- Full center view recorded $\rightarrow$ Every pixel is covered at least once
- Task: Find relationship between available pixel in distorted image and same pixels in the reference image
- Use this relationship to predict the missing pixels
- Classical and neural network-based approach possible



Registration examples



- False color images can be generated using combinations of 3 channels
- RGB $\rightarrow$ middle row of CAMSI; 750 nm, 850 nm, 950 nm $\rightarrow$ top row

Conclusion

- Camera Array for Multispectral Imaging
- Big advantage: Snapshot capabilities and high spatial resolution
- Applications: Material classification, agriculture, forensics, medicine, ...
- Reconstruction pipeline necessary to build a consistent multispectral datacube
  - Calibration to compensate manufacturing deviations
  - Cross-spectral disparity estimation
  - Warping of peripheral views to center view
  - Cross-spectral reconstruction of occluded pixels
- False color images: Show three arbitrary spectral bands as RGB image