Mixed-Resolution View Synthesis Using BM3D-Refined Image Merging

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BM3D-verfeinerte Zwischenbildsynthese für unterschiedlich aufgelöste Referenzansichten

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Outline

- **Motivation**

- **Mixed-Resolution View Synthesis**

- **BM3D-Refined Image Merging**

- **Simulation Results**

- **Conclusion**

Motivation

- Full-resolution view synthesis is a key issue in the 3D video domain.

- Responds to the question how to synthesize a desired intermediate view from adjacent reference views.
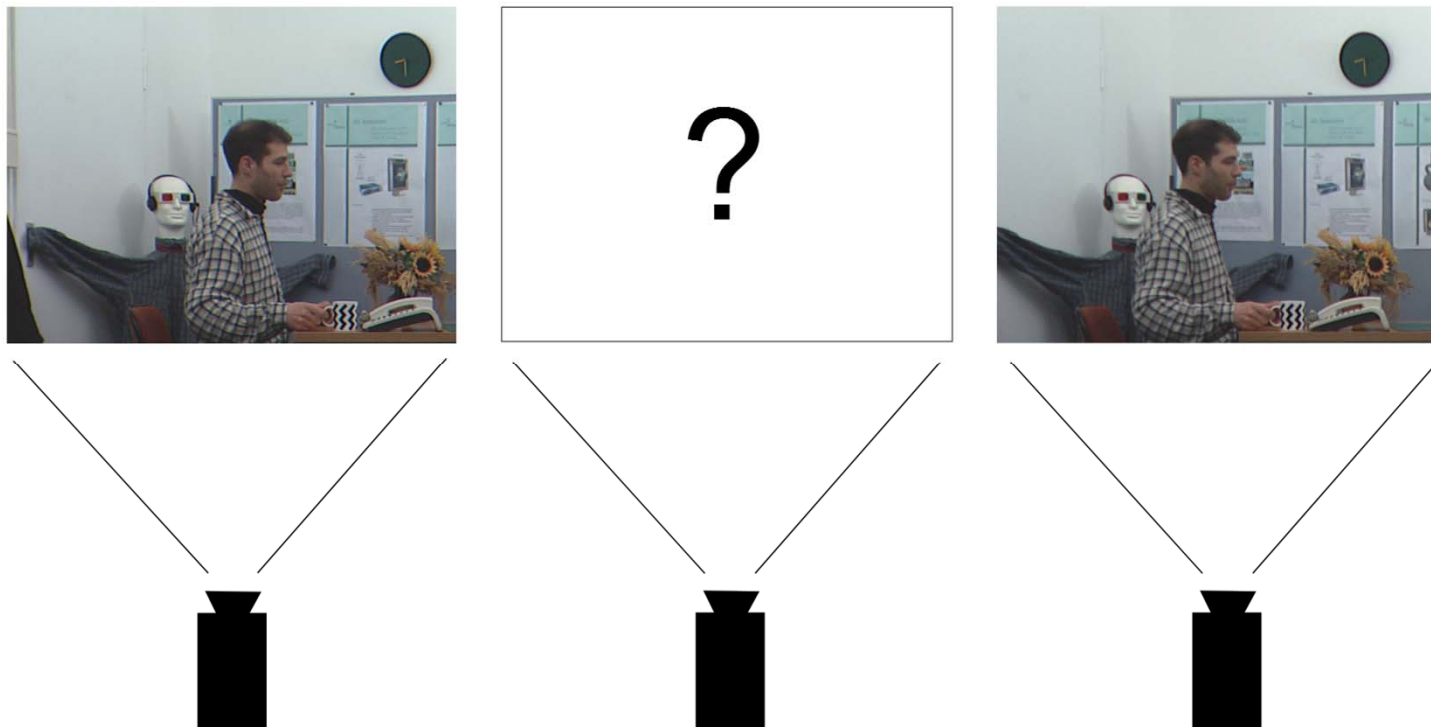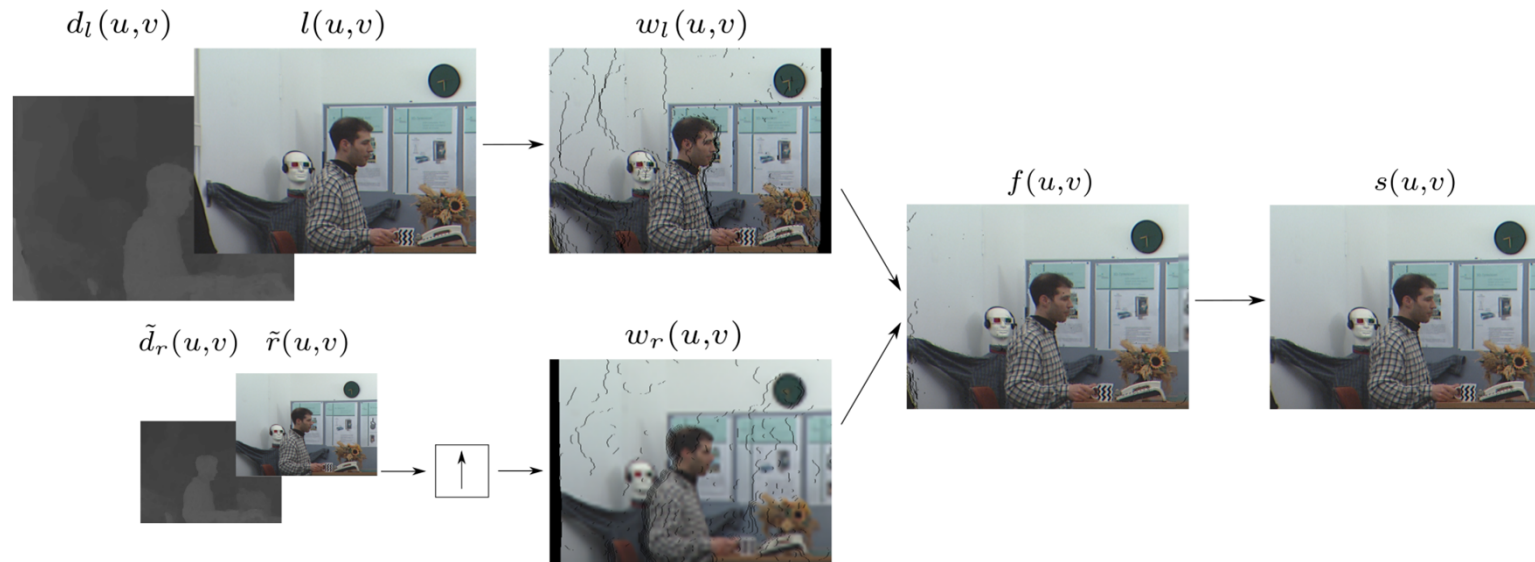
Motivation

- Mixed-resolution (MR) setup useful in various applications, due to:
    - binocular suppression theory
    - less costs with respect to the used camera array
    - less data to transmit
    - less data to store
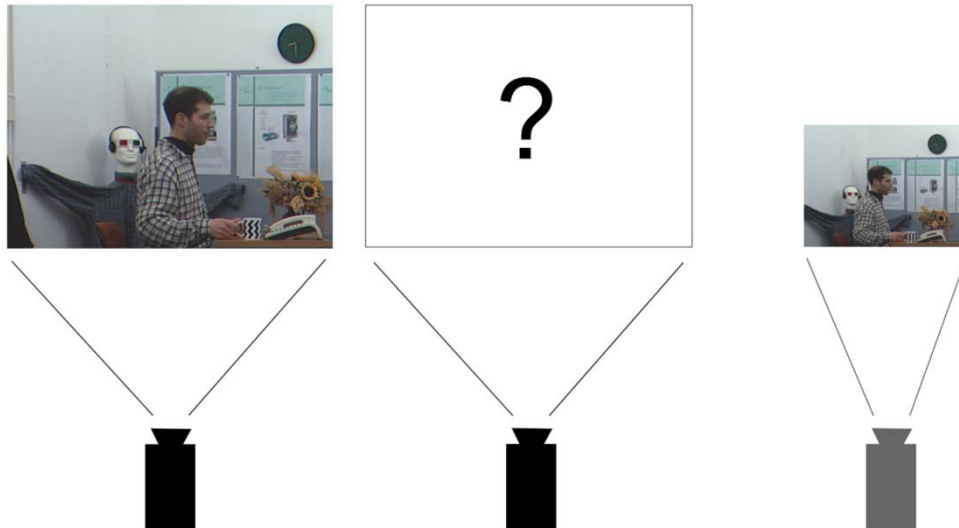
How to synthesize a high resolution intermediate view from neighboring reference views with different spatial resolutions?
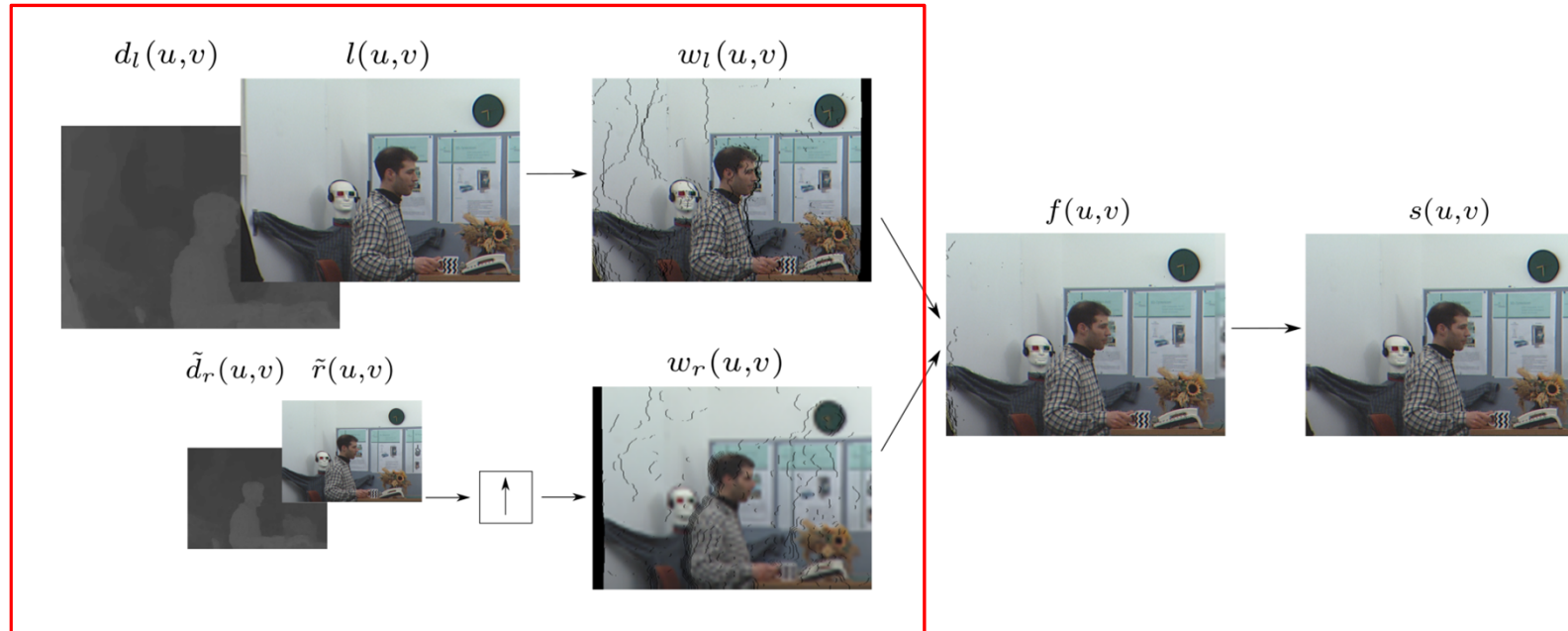
Mixed-Resolution View Synthesis

- Basic overview over the view synthesis algorithm in a MR setup

- Basically 3 steps: - Image warping
  - Image merging
  - Hole filling

Richter et al.: BM3D-Refined Image Merging

Chair of Multimedia Communications and Signal Processing
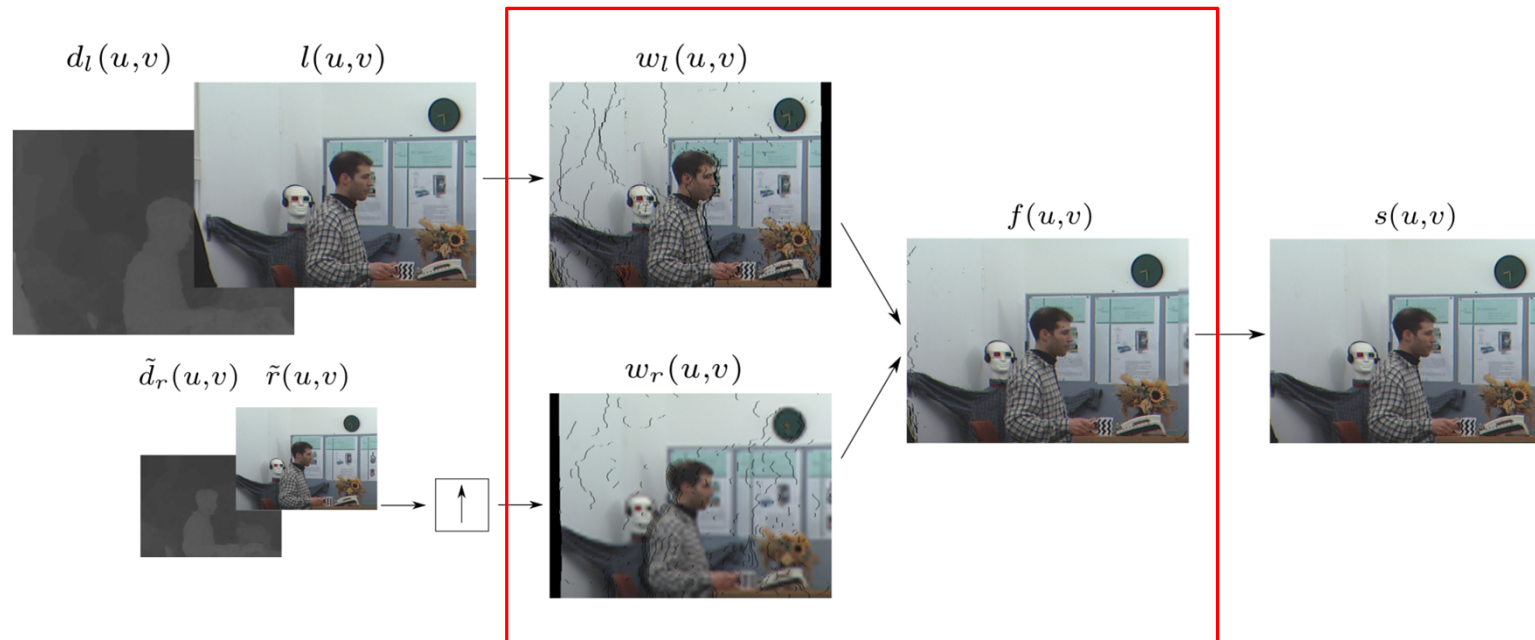
Mixed-Resolution View Synthesis

- Image warping:

- Two reference views are warped into the desired intermediate view via their corresponding depth maps.

# Mixed-Resolution View Synthesis

- Image merging:

- Both obtained warped images are merged together.

Mixed-Resolution View Synthesis

- Image merging:

$$
f(u,v) = \begin{cases} w_l(u,v), & \text{if}(u,v) \in \mathcal{H}_r \backslash \mathcal{H}_l \\ w_r(u,v), & \text{if}(u,v) \in \mathcal{H}_l \backslash \mathcal{H}_r \\ w_l(u,v), & \text{if}(u,v) \in \bar{\mathcal{H}}_l \cap \bar{\mathcal{H}}_r \\ 0, & \text{if}(u,v) \in \mathcal{H}_l \cap \mathcal{H}_r \end{cases}
$$

L-high	R-low
✓	■
■	✓
✓	✓
■	■

- $\mathcal{H}_l$ respectively $\mathcal{H}_r$ describe the set of holes in the related warped images $w_l(u,v)$ and $w_r(u,v)$.

Mixed-Resolution View Synthesis

- Hole filling:
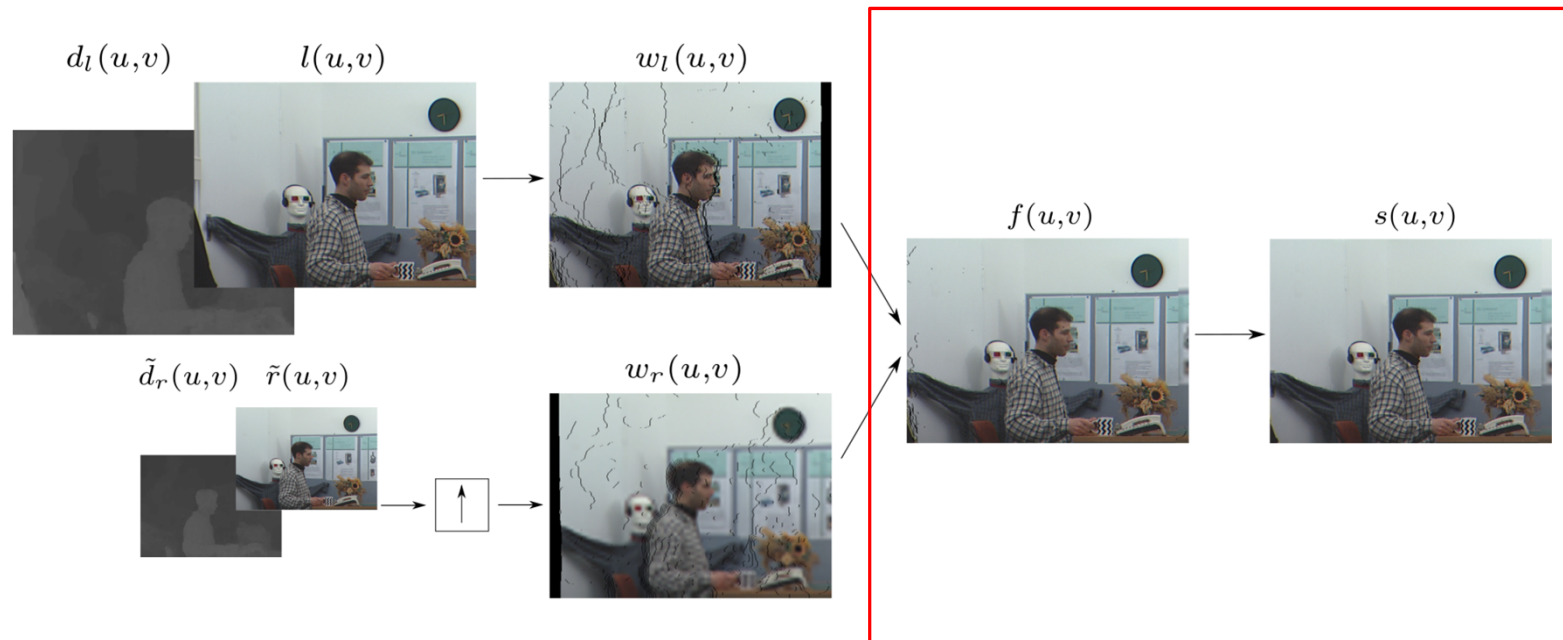
- A hole-filling algorithm is applied on the merged image to fill the remaining holes and create the final synthesized view.

Mixed-Resolution View Synthesis

- Problem:

  Some of the information in the merged image has to be taken from the low-resolution reference!

synthesized detail of *alt_moabit* sequence in FR-setup

synthesized detail of *alt_moabit* sequence in MR-setup

Insertion of interpolated and hence blurred regions from the low-resolution reference leads to annoying visible artifacts in the synthesized view.

Mixed-Resolution View Synthesis

- Refinement:
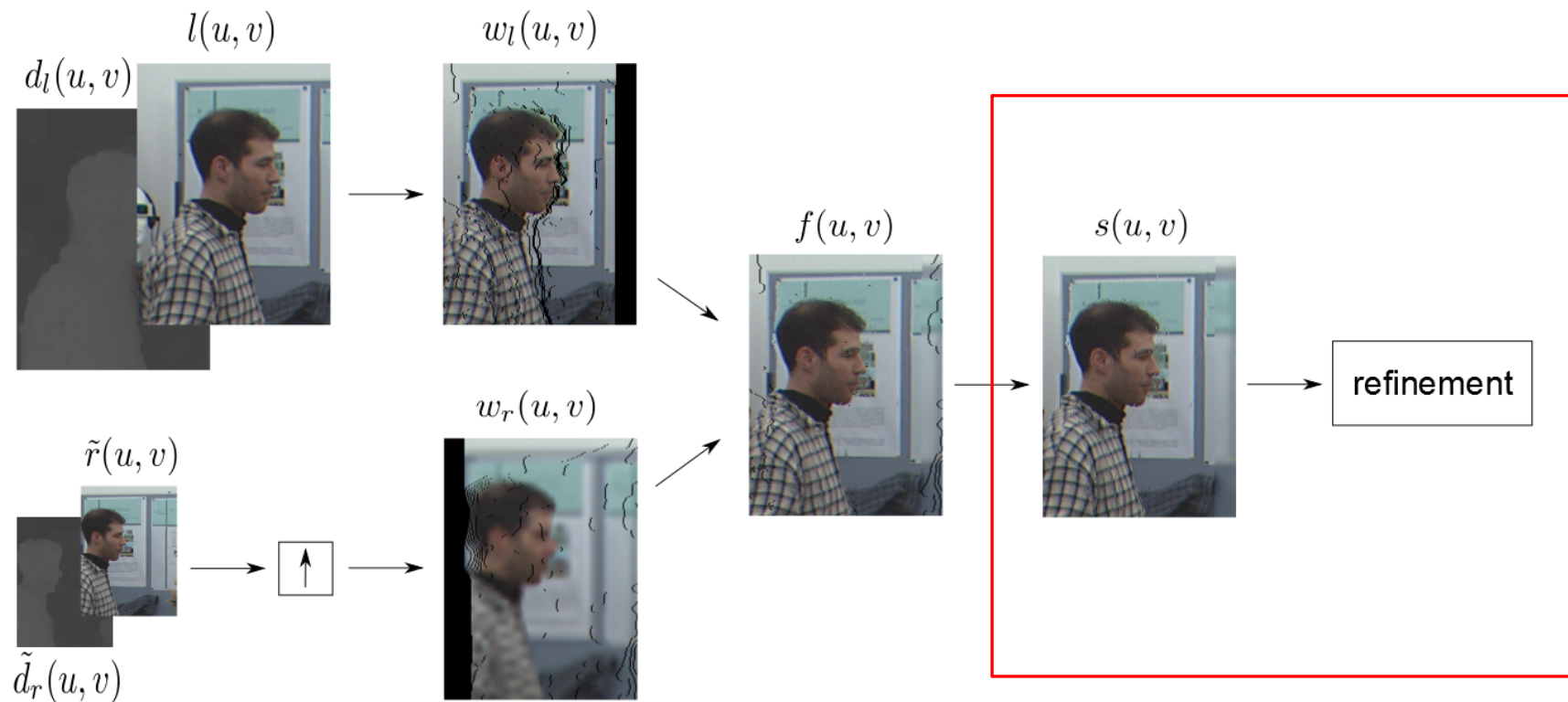
BM3D-Refined Image Merging

- BM3D [1]:
  - State-of-the-art for image denoising
  - 2 iterations: grouping, 3D transformation, filtering, aggregation

- Goal:

  Refine a pixel inserted from the low-resolution reference and adapt it to its high-resolution surrounding.
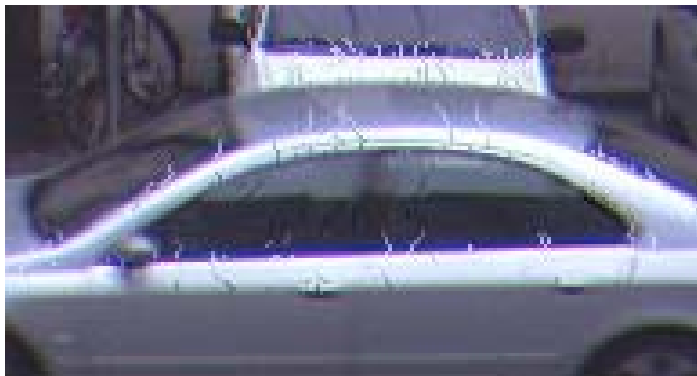
[1]: K. Dabov, A. Foi, V.Katkovnik, K. Egiazarian: „Image Denoising by Sparse 3D Transform-domain Collaborative Filtering",
IEEE Trans. On Image Processing, vol. 16, no. 8, 2080-2095, 2007

BM3D-Refined Image Merging

- 1st iteration:
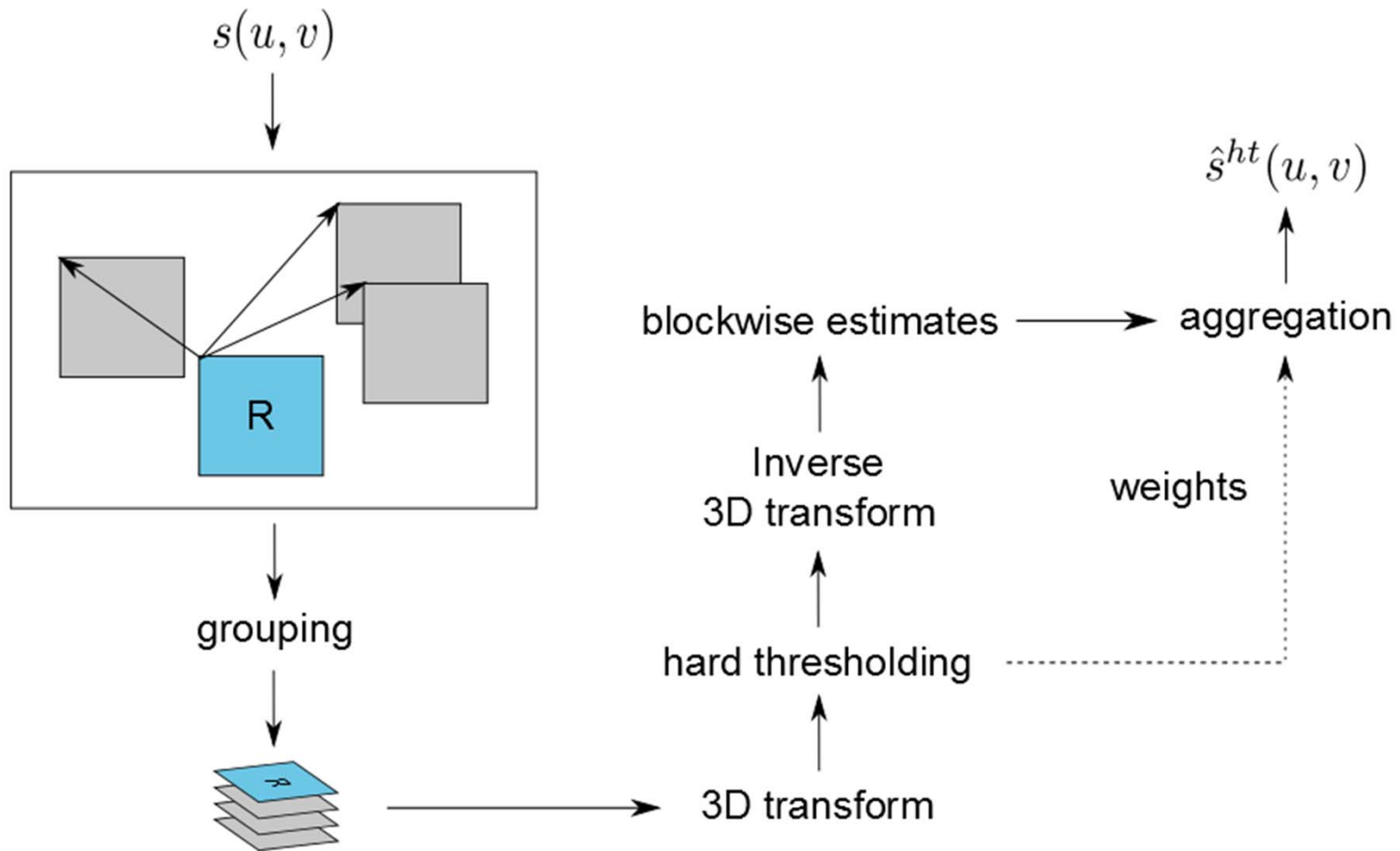
BM3D-Refined Image Merging

- **2nd iteration:** Take result from 1st iteration as initial estimation
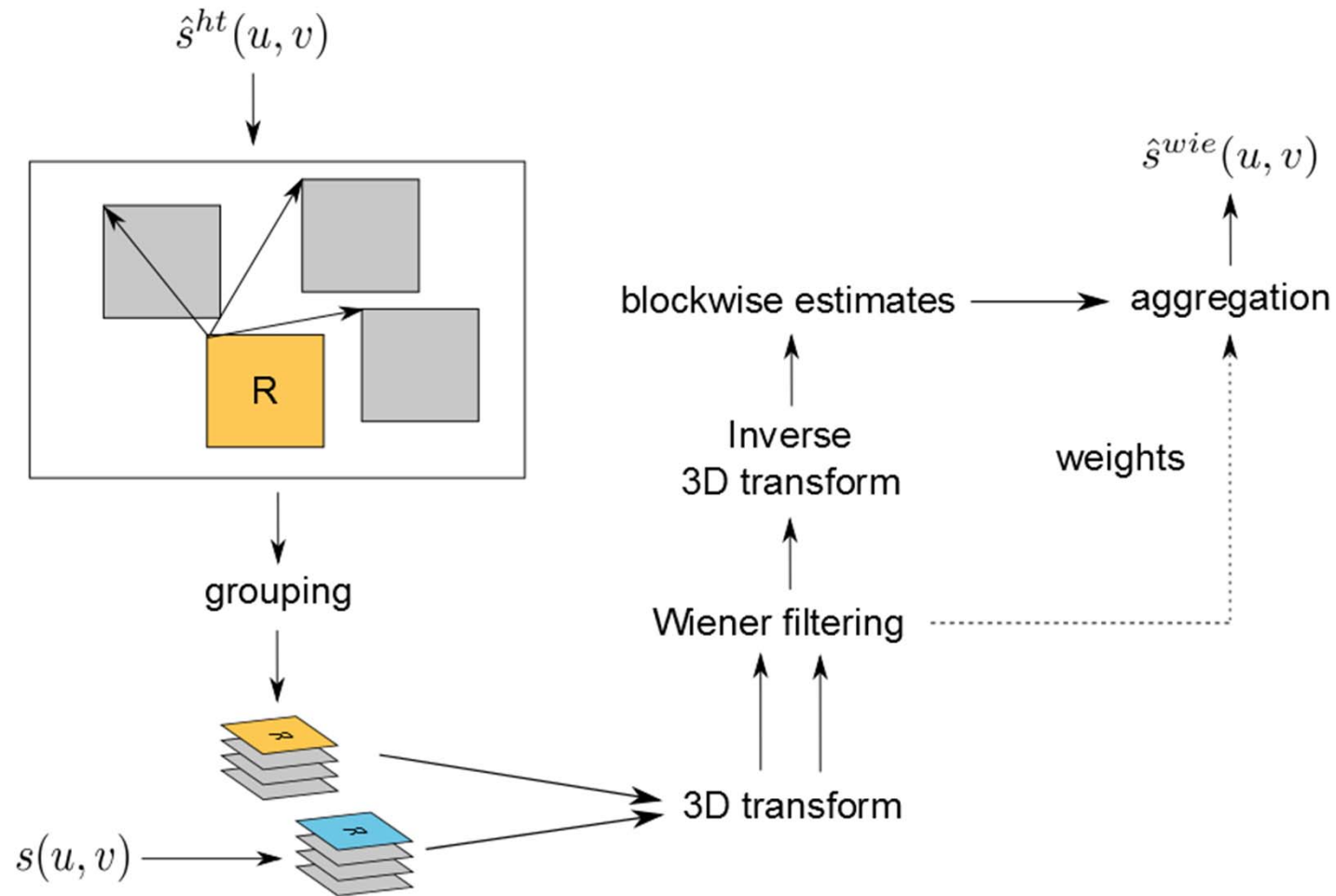
BM3D-Refined Image Merging

- Take refined pixel values only at positions which were inserted from the low-resolution reference.

$$
s^{BM3D}(u, v) = \begin{cases} s(u, v), & \text{if}(u, v) \in \bar{\mathcal{H}}_l \\ \hat{s}^{wie}(u, v), & \text{if}(u, v) \in \mathcal{H}_l \end{cases}
$$
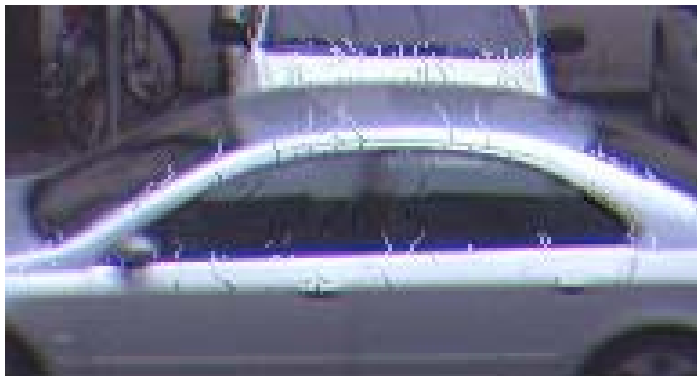
Simulation Results

- Simulation Setup:

    - Multiview test-sequences: *alt_moabit, book-arrival, pantomime, kendo*

    - Generation of low-resolution view:
        - Filtering, downsampling, upsampling via bicubic interpolation
        - Used downsampling-factors: 2,4,6

Simulation Results

	$\downarrow$	*book-arrival*	*alt_moabit*	*kendo*	*pantomime*
$PSNR_{FR}$	-	32,99	29,82	34,48	33,89
$\Delta\,PSNR_u$	2	-0,04	-0,07	-0,05	0,00
$\Delta\,PSNR_{NLM}$	2	0,03	**-0,03**	0,00	0,02
$\Delta\,PSNR_{BM3D}$	2	**0,04**	**-0,03**	**0,01**	**0,03**
$\Delta\,PSNR_u$	4	-0,33	-0,37	-0,31	-0,07
$\Delta\,PSNR_{NLM}$	4	-0,16	-0,14	-0,18	-0,03
$\Delta\,PSNR_{BM3D}$	4	**-0,09**	**-0,07**	**-0,10**	**0,01**
$\Delta\,PSNR_u$	6	-0,60	-0,62	-0,59	-0,15
$\Delta\,PSNR_{NLM}$	6	-0,34	-0,25	-0,39	-0,08
$\Delta\,PSNR_{BM3D}$	6	**-0,25**	**-0,11**	**-0,24**	**-0,02**

book-arrival

alt_moabit

kendo

pantomime

PSNR evaluated over the whole synthesized image

Simulation Results

	↓	*book-arrival*	*alt_moabit*	*kendo*	*pantomime*
$PSNR_{FR}$	-	31,82	29,65	32,48	28,63
$\Delta\,PSNR_u$	2	-0,71	-2,30	-1,33	0,47
$\Delta\,PSNR_{NLM}$	2	-0,51	-1,15	-0,12	2,54
$\Delta\,PSNR_{BM3D}$	2	**-0,30**	**-1,08**	**0,22**	**3,93**
$\Delta\,PSNR_u$	4	-3,58	-6,73	-5,36	-3,12
$\Delta\,PSNR_{NLM}$	4	-2,04	-3,79	-3,86	-1,19
$\Delta\,PSNR_{BM3D}$	4	**-1,30**	**-2,09**	**-2,57**	**1,53**
$\Delta\,PSNR_u$	6	-5,28	-8,75	-7,68	-5,46
$\Delta\,PSNR_{NLM}$	6	-3,65	-5,48	-6,17	-3,51
$\Delta\,PSNR_{BM3D}$	6	**-2,82**	**-3,06**	**-4,60**	**-0,32**

PSNR evaluated over refined pixels

book-arrival

alt_moabit

kendo

pantomime

Simulation Results

unrefined detail of *alt_moabit* sequence and a downsampling-factor of 6

Simulation Results

NLM-refined detail of *alt_moabit* sequence and a downsampling-factor of 6

Simulation Results

BM3D-refined detail of *alt_moabit* sequence and a downsampling-factor of 6

LMS

Conclusion

- A desired intermediate camera perspective is synthesized by two adjacent reference views with different spatial resolutions.

- Some of the information in the synthesized view can only be seen from the low-resolution view.

- Introducing interpolated and hence blurred regions from the low-resolution reference leads to annoying visual artifacts.

- BM3D refinement is an effective method for increasing image sharpness in those low-resolution areas.

- BM3D refinement achieves PSNR gains of up to 0.51 dB with respect to an unrefined MR setup.