Image Super-Resolution Using T-Tetromino Pixels

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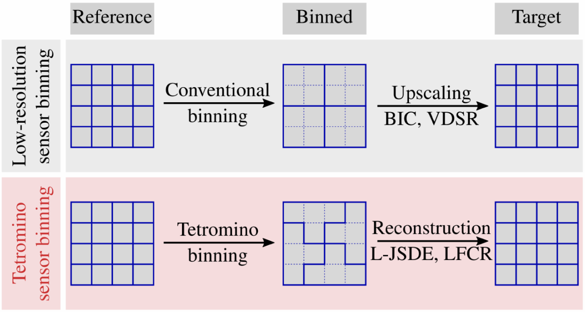
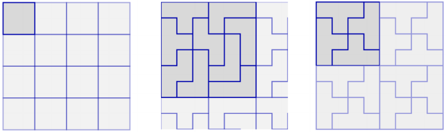
1. Problem Statement

- Pixel binning is used in low-light and high frame rate scenarios
- Single-image super-resolution can be used for upscaling (e.g., VDSR [Kim2016])
- Novel tetromino-shaped pixel binning proposed for higher image quality
- Locally fully connected reconstruction network (LFCR) used for reconstruction [Grosche2021]
- Proposed method achieves up to +1.92 dB gain in PSNR compared to conventional SISR



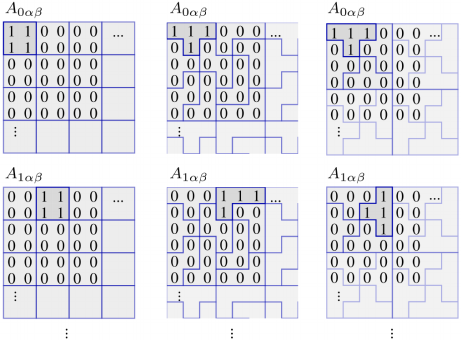
2. Sensor Layouts and Compressed Sensing

(a) Low-resolution sensor | (b) Tetromino sensor from [16] | (c) 4×4 T-tetromino sensor (prop.)

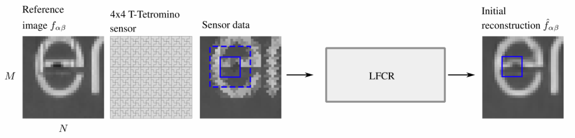


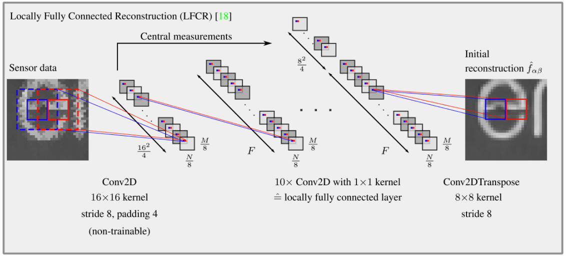
- Measurement can be written in terms of Compressed Sensing
  $$y_i = \sum_{\alpha=0}^{M-1} \sum_{\beta=0}^{N-1} A_{i\alpha\beta} f_{\alpha\beta},$$
- Coherence
  $$\mu = \max_{(\sigma,\rho)\neq(\tilde{\sigma},\tilde{\rho})} \left(\frac{\left| \sum_{i=0}^{L-1} A'_{i\sigma\rho} \left(A'_{i\tilde{\sigma}\tilde{\rho}}\right)^* \right|}{\sqrt{\sum_{i=0}^{L-1} |A'_{i\sigma\rho}|^2} \sqrt{\sum_{i=0}^{L-1} |A'_{i\tilde{\sigma}\tilde{\rho}}|^2}} \right)$$

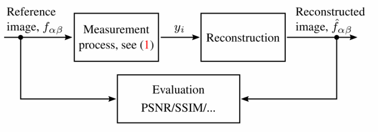
	Coherence μ
Low-resolution sensor	1.00
Tetromino sensor from [16]	0.78
4x4 T-tetromino sensor (prop.)	0.93



3. Experimental Results







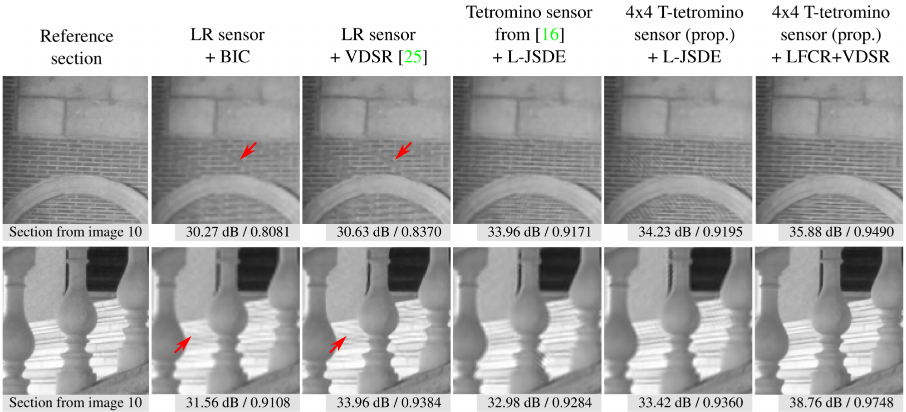
- Different tetromino layouts

	L-JSDE [19]	SPL [32]	LFCR+VDSR [18]
Tetromino sensor from [16]	34.27	31.55	-
Geared 8x8 T-tetromino	34.30	31.71	36.63
4x4 T-tetromino (prop.)	**34.49**	**31.76**	**37.32**

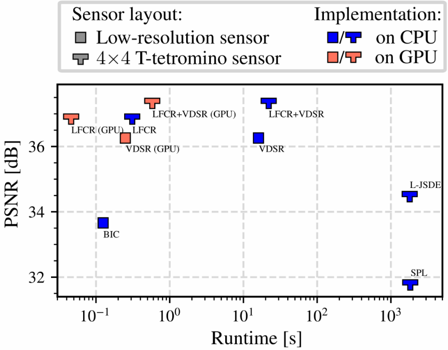
- Comparison with 2x2 binning/low-resolution

	TECNICK [2]	Urban100 [23]
Low-resolution sensor		
+ BIC [41]	33.66 / 0.9631	25.67 / 0.8820
+ VDSR [25]	36.20 / 0.9746	28.92 / 0.9299
+ LFCR+VDSR [18]	36.01 / 0.9739	28.73 / 0.9283
4×4 T-tetromino (prop.)		
+ L-JSDE [19]	34.49 / 0.9695	26.94 / 0.9050
+ LFCR (only) [18]	36.84 / 0.9771	29.59 / 0.9386
+ LFCR+VDSR [18]	**37.32 / 0.9785**	**30.54 / 0.9475**

4. Visual Comparison



5. Algorithm Runtime



6. Conclusions

- Investigated tetromino pixels for novel sensor layout concepts
- A simple 4x4 cell is proposed
- Superior reconstruction quality than larger tetromino tiling
- Superior reconstruction quality than conventional 2x2 binning
- Reduce aliasing artifacts compared to single-image super-resolution
- +1.62 dB in PSNR compared to 2x2 binning with VDSR

[Kim2016] J. Kim, J. K. Lee, and K. M. Lee. Accurate image super-resolution using very deep convolutional networks. In *Proc. Conference on Computer Vision and Pattern Recognition*, pp. 1646–1654, Las Vegas, June 2016.

[Grosche2021] S. Grosche, F. Brand, and A. Kaup. A novel end-to-end network for reconstruction of non-regularly sampled image data using locally fully connected layers. In *Proc. IEEE International Workshop on Multimedia Signal Processing (MMSP)*, pages 1–6, Tampere, Oct. 2021.