DETAIL-PRESERVING COMPRESSIVE SENSING RECOVERY BASED ON CARTOON TEXTURE DECOMPOSITION

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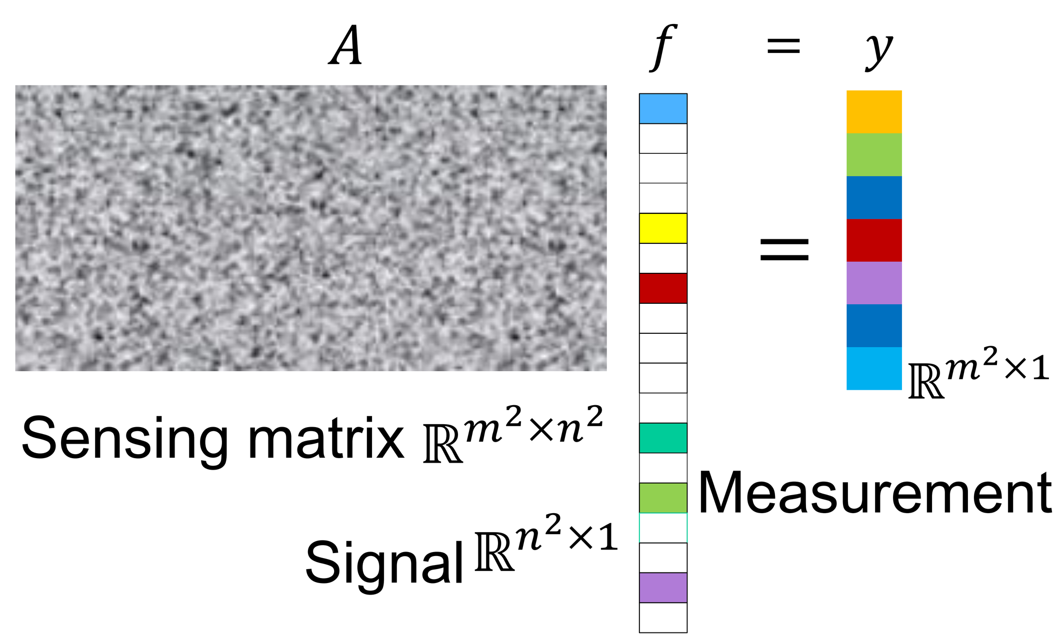
1. Abstract

- **Total Variation** (TV) preserves edges well but suffers from staircase artifacts and loss of details.
- Nonlocal structure helps TV to overcome the drawbacks by adding regularization terms.
- Utilize relationship between cartoon texture image decomposition and residual recovery.
- We propose a detail-preserving reconstruction method for TV based Compressive Sensing (CS) recovery at low subrate using cartoon texture image decomposition.

2. Compressive Sensing



Large size sensing matrix demands

- High computational complexity
- Large memory requirement

Kronecker CS

- Separate H & V sensing matrices each of which has smaller size
- Enable frame based sensing

$$A = R\otimes G^T \quad R, G\in\mathbb{R}^{m\times n}$$

$$\|Af-y\|_2^2 = \|RFG-Y\|_2^2$$

3. Cartoon Texture Decomposition

- Split image into cartoon & texture

$$F = F_C + F_T,$$

- TV's output at k^{th} iteration looks like cartoon image

$$F_C^k = CSrec(Y^k),$$

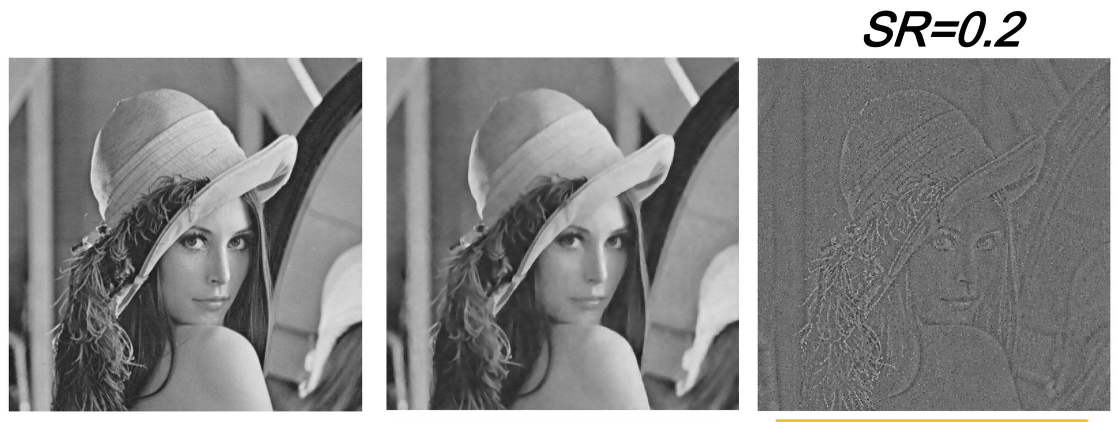
- Decomposition in measurement domain:

$$Y^k = Y_C^k + Y_T^k,$$

- Texture remains in residual meas.

$$F_T^k = CSrec(Y^k - RF_C^k G)$$

SR=0.2



Lenа Cartoon Texture

Cartoon and texture images of the proposed method at 8^{th} iteration

4. TV with nonlocal regularization

- Exploit nonlocal structure in spatial domain
- TV with spatial nonlocal regularization [6]

$$min_F\ TV(F)+\frac{\mu}{2}\|RFG-Y\|_2^2+\frac{\gamma}{2}\|F-\mathcal{G}(F)\|_2^2,$$

$$TV(F)=\begin{cases}\|\nabla_x F\|_1+\|\nabla_y F\|_1\\ \sum_{i,j}\sqrt{\left|(\nabla_x F)_{i,j}\right|^2+\left|(\nabla_y F)_{i,j}\right|^2}\end{cases}$$

$\mathcal{G}(.)$: *nonlocal preserving filter*

- We use split Bregman [4] method by replacing $V=F, D_m=\nabla_m F$, and adding parameters B_x, B_y, W

$$\min_{F,V,D_x,D_y} TV(F)+\frac{\mu}{2}\|RFG-Y\|_2^2+\frac{\gamma}{2}\|F-\mathcal{G}(F)\|_2^2$$
$$+\frac{\lambda}{2}\|D_x-\nabla_x V-B_x\|_2^2+\frac{\lambda}{2}\|D_y-\nabla_y V-B_y\|_2^2$$
$$+\frac{\nu}{2}\|F-V-W\|_2^2,$$

5. Proposed Recovery Method

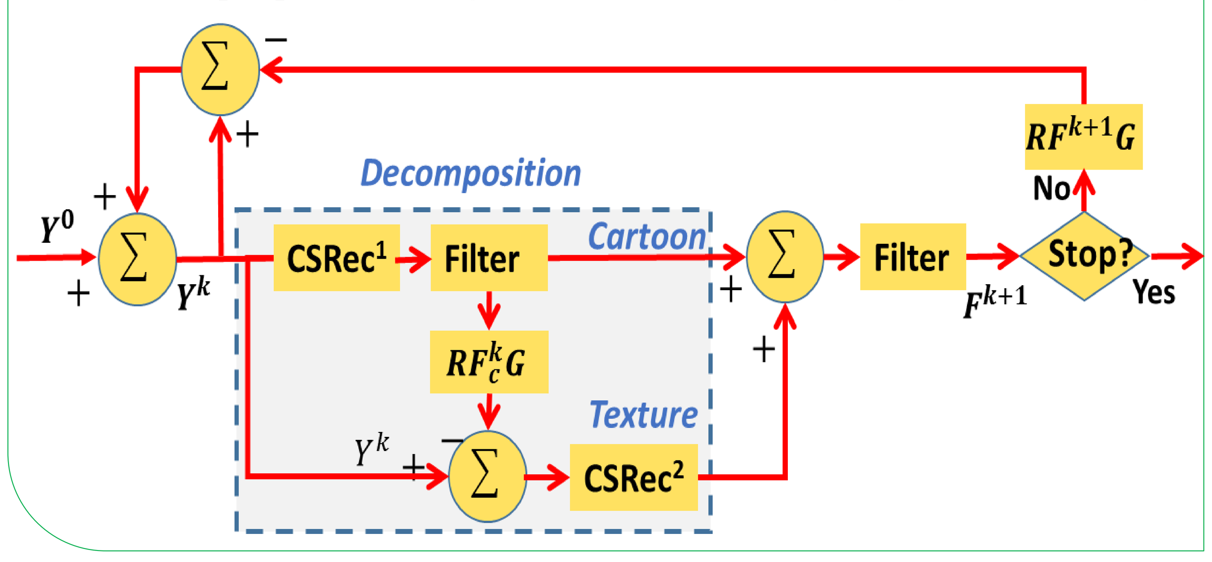
Decomposition based **TV** recovery (**DTV**):

- Iteratively recover cartoon and texture
- Iterative filtering:
  - Reduce noise & staircase artifact
  - Turn TV output into cartoon image

***DTV-NL(BM3D)**: **CSRec**[1,2]: TV[5], **Filter:** NLM (BM3D)*

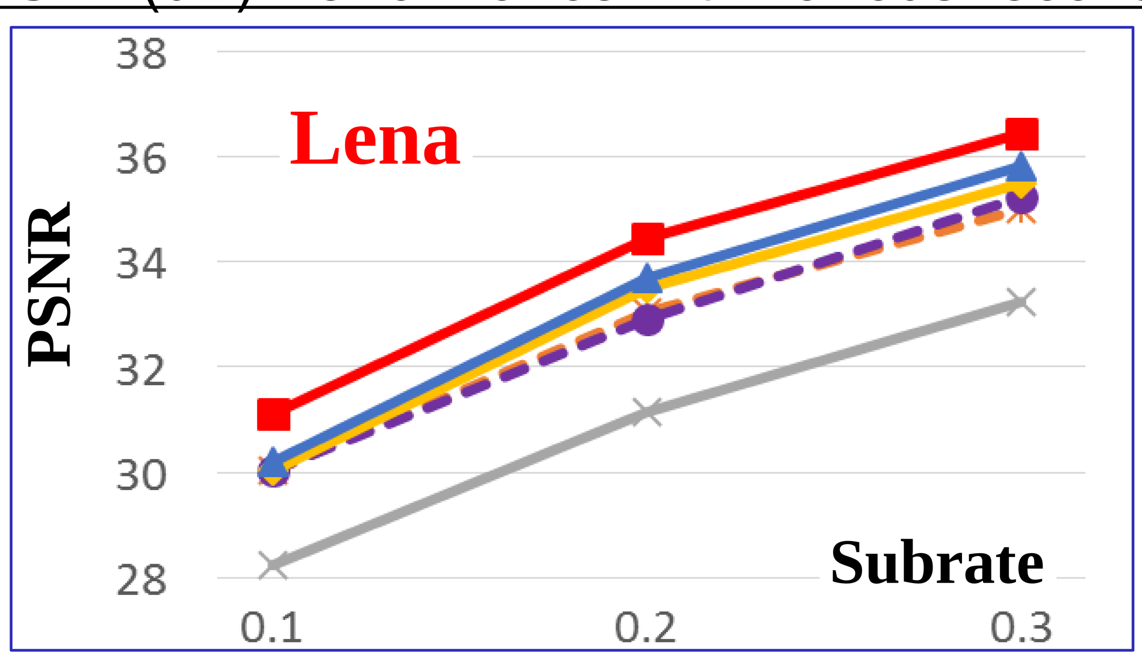
***DTV-NLR1**: **CSRec**[1]: TVNLR1[6],**CSRec**[2]: TV[5],**Filter:** BM3D*

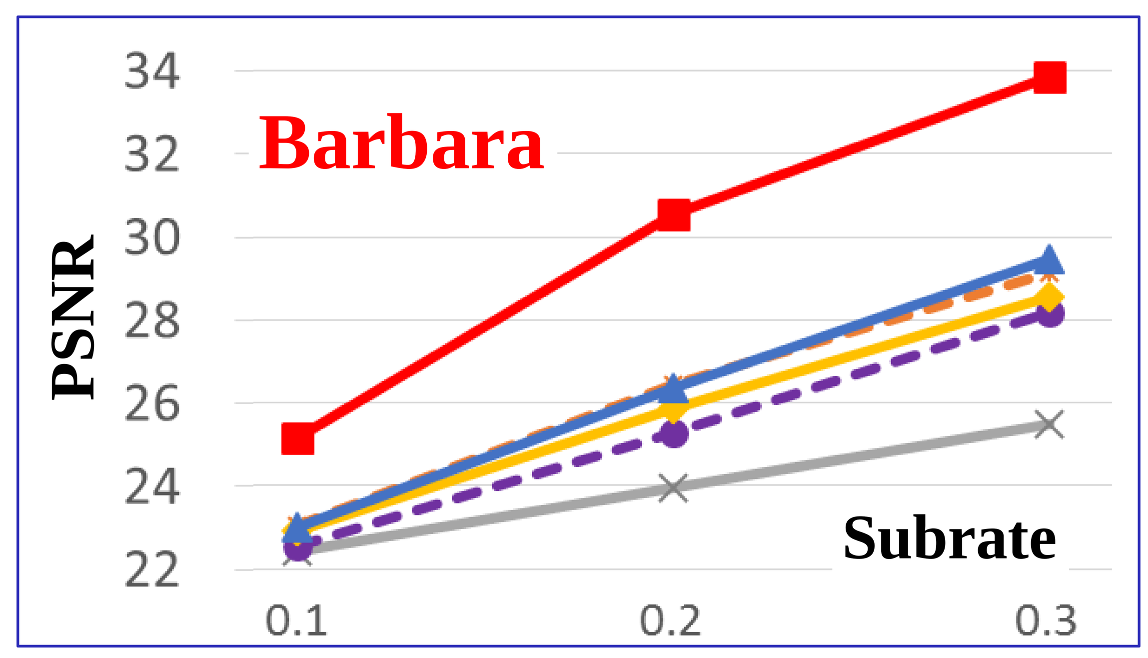
***TV+BM3D[16]**: iteratively recover residual, (only texture part)*

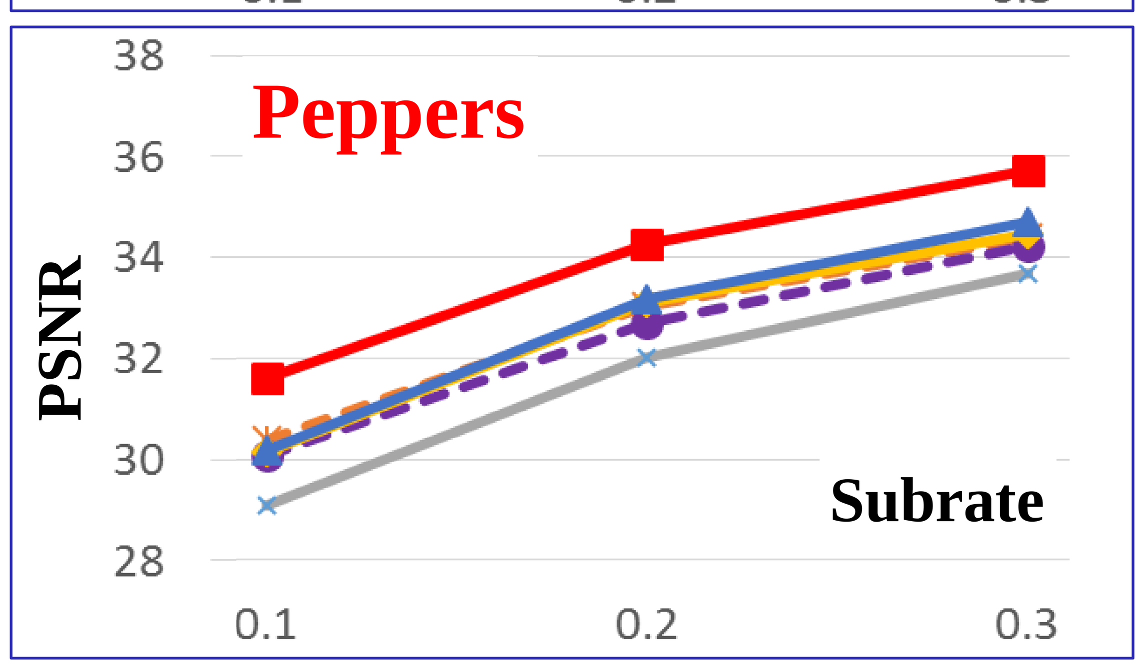


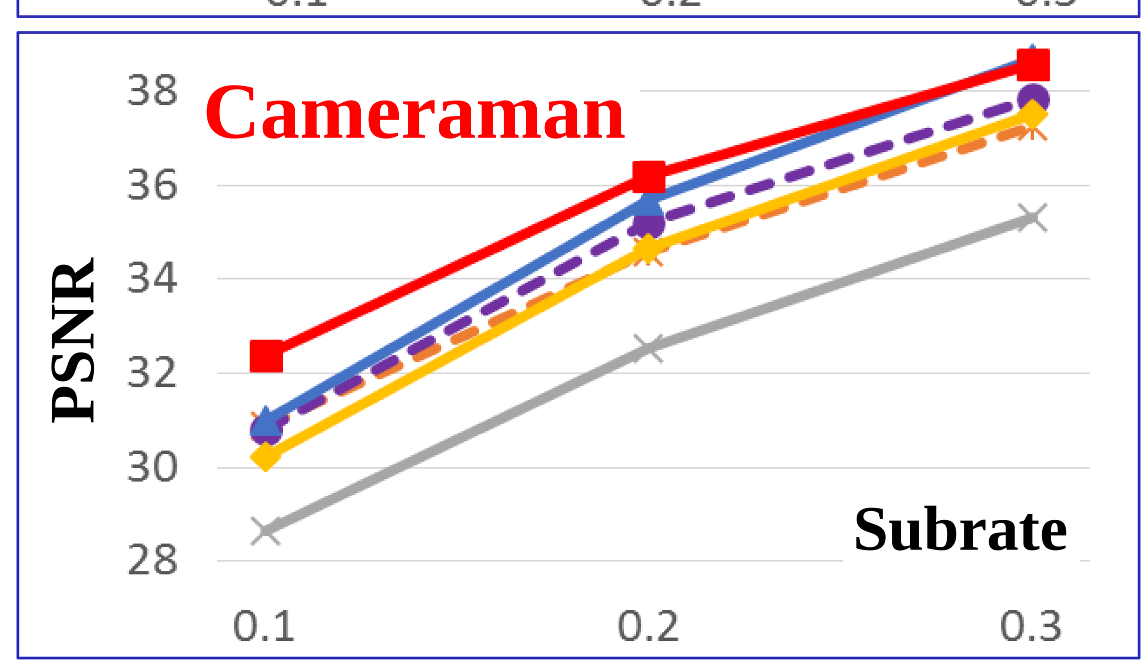
6. Experimental Results

PSNR(dB) Performance with various *recovery methods*









TV[5] TVNLR1[6] TV+BM3D[16] DTV-NL* DTV-BM3D* DTV-NLR1* *Proposed (*)*

Visual quality with various *recovery methods*(subrate 0.2)

Ground truth TVNLR1 [6] TV+BM3D [16] DTV-NL* DTV-BM3D* DTV-NLR1*

7. Conclusions

By exploiting nonlocal structure-preserving filters and based on cartoon image decomposition, the proposed method

✓ Plays an important role in keeping edges and textures of image.

✓ Outperforms state of the art recovery methods in terms of PSNR and visual quality.

✓ Can work with other TV-based recovery methods and structure-preserving filters.

References

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