Exploiting Self-Similarities for Single Frame Super-Resolution

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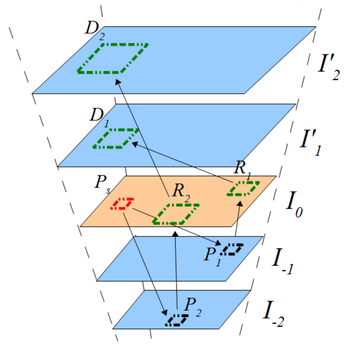
Problem

- **Single Frame Super-Resolution**
  - Reconstruct high-resolution images from low-resolution one

- **Super-Resolution Methods and Their Drawbacks**
  - **Interpolation-based**
    - usually result in over-smoothed edges
  - **Reconstruction-based**
    - require multiple low-resolution image observations
  - **Example-based**
    - require external dataset to learn low-high resolution patch mapping

Main Idea

- **Patch Similiarity in Images**
  - Combining reconstruction-based and example-based method by exploiting self-similarities in natural images



- **Group Structural Sparisity**
  - Learning the mapping from low-resolution to high-resolution patches with non-local sparse model (i.e. exploiting structural sparisity)

Algorithm

- **Generate Example Pairs by Exploiting Self-Similarity**
  - Image pyramid construction
  - For each patch, find k-nearest neighbor patches
  - Generate training low/high resolution patch pairs
- **Learning Dictionary with Group Sparsity**
  - Cluster training pairs
  - For each cluster, solve the group sparse coefficients as

$$\min_{\boldsymbol{A}_i} \|\boldsymbol{A}_i\|_{1,2} \text{ s.t. } \|\boldsymbol{Y}_i - \boldsymbol{D}\boldsymbol{A}_i\|_F \leq \sqrt{n_i}\delta$$

  where $\|\boldsymbol{A}\|_{1,2} = \sum_{k=1}^{n} \|\boldsymbol{R}^k\|_2$ and $\boldsymbol{R}^k$ is $\boldsymbol{A}$'s $\boldsymbol{k}$-th row
  - Dictionary update using the K-SVD algorithm

$$\boldsymbol{D} = \underset{\boldsymbol{D}}{\text{argmin}} \|\boldsymbol{Y} - \boldsymbol{D}\boldsymbol{A}\|_F \text{ s.t. } \|\boldsymbol{D}_j\|_2 = 1 \ \ \forall j$$

- **Reconstruct High-Resolution Images**
  - Cluster low-resolution patches
  - For each cluster, solve group sparse coefficients
  - Reconstruct high-resolution patches using the learned dictionary

Experimental Results

- **Experiments Setup**
  - Image pyramid leve $\boldsymbol{n} = 6$
  - Number of nearest neighbor $\boldsymbol{m} = 9$
  - Scaling factor $\boldsymbol{s} = 3$
  - Apply only on luminance channel
  - Solving group sparsity: SPGL1 package

(a) Original (b) Yang et al. (c) Glasner et al. (d) Proposed

(a) Bicubic (b) Yang et al. (c) Proposed

Experimental Results

- **Performance Comparison**

(a) Glasner et al. (b) Yang et al. (c) Proposed

Conclusion

- A super-resolution algorithm by exploiting self-similarities in the forms of example generation and dictionary learning with group sparsity