Exploiting Self-Similarities for Single Frame Super-Resolution
Chih-Yuan Yang, Jia-Bin Huang, Ming-Hsuan Yang
Electrical Engineering and Computer Science, University of California, Merced
cyang35@ucmerced.edu, jbhuang@ieee.org, mhyang@ucmerced.edu
code available: http://eng.ucmerced.edu/people/cyang35

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 Similarity in Images
  - Combining reconstruction-based and example-based method by exploiting self-similarities in natural images

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

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
  \[
  \min_{A} \| A \|_{1,2} \text{ s.t. } Y_{i} = DA_{i} \leq \sqrt{n_{i}} \delta
  \]
  where \( \| A \|_{1,2} = \sum_{k=1}^{n_{k}} \| R_{k} \|_{2} \) and \( R_{k} \) is \( A \)’s \( k \)-th row
  - Dictionary update using the K-SVD algorithm
  \[
  D = \text{argmin}_{D} \| Y - DA \|_{F} \text{ s.t. } \| D_{j} \|_{2} = 1 \forall j
  \]

• 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 level \( n = 6 \)
  - Number of nearest neighbor \( m = 9 \)
  - Scaling factor \( s = 3 \)
  - 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

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