Single Image Super-Resolution
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Super-Resolution: To obtain a high-resolution (HR) image, given low-resolution (LR) image(s)

Motivation
- Not feasible to install expensive high-end cameras in all applications e.g. cell phones, surveillance cameras, some computer vision applications
- Medical imaging, Satellite imaging find the resolution from current technology insufficient, e.g. Doctors can make better diagnoses with HR images.
- Hence, a need to increase the resolution of images using image processing techniques.

Results
- Not feasible to install expensive high-end cameras in all applications e.g. cell phones, surveillance cameras, some computer vision applications
- Medical imaging, Satellite imaging find the resolution from current technology insufficient, e.g. Doctors can make better diagnoses with HR images.
- Hence, a need to increase the resolution of images using image processing techniques.

#1 Learning the LR-HR patch relationships [1]
Basic idea: Given dictionary $D_l$ which admits a sparse representation for a LR patch $y$ (reshaped into a column), reconstruct HR patch $x$ from a coupled dictionary $D_h$.
$$\min_\alpha \| D_l \alpha - (y - \bar{y}) \|_2^2 + \lambda \| \alpha \|_1$$
$x = D_h \alpha + \bar{y}$

I1-regularization for sparsity

Constructing compact sparsity-inducing dictionaries from training data: biconvex optimization problem

Modifications:
- Consider overlapping patches, add cost in objective penalizing inconsistency in overlapped region
- Instead of raw patches, use features that are expected to be more informative (e.g. gradients)

#2 Harnessing patch redundancy
- Natural images tend to contain repetitive visual content (patch redundancy)

Framework
Construct a cascade of HR images, $\{I_l\}_{l=1}^n$ till we reach $I_n = H$. Each $I_l$ must satisfy
$$I_l = (H * B_{n-l} \downarrow)$$
- Impose above constraints for each $\{I_l\}_{l=1}^n$ by finding similar patches with in and across LR scales.
- Weighted least squares problem; weight for a constraint determined by patch similarity.

Results
- Nearest Neighbor
- Bicubic
- Approach #1
- Approach #2
- State-of-the-art

Unification of two widely used super resolution methods:
- Classical SR (similar patches at sub-pixel misalignments within same scale)
- Example SR (LR-HR correspondence using similar patches across scales)

Approach #1
State-of-the-art