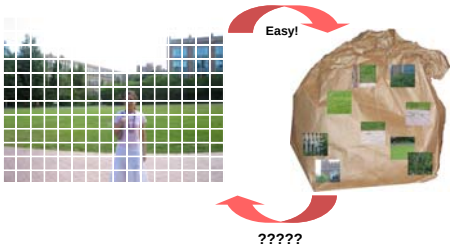
The patch transform and its applications to image editing

Taeg Sang Cho[1], Moshe Butman[2], Shai Avidan[3], William Freeman[1,3]
CSAIL-MIT[1], Bar-Ilan Univ[2]. Adobe Inc.[3]

Motivation

From a set of non-overlapping patches from an image, can we reconstruct the image?



Solving jigsaw puzzle is NP-complete!

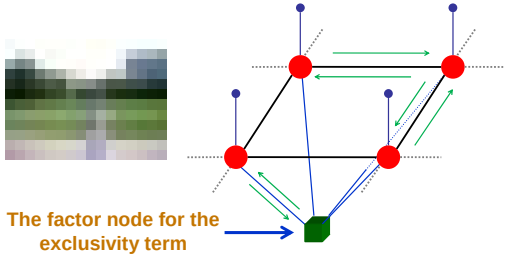
The image model

$$P(\mathbf{x}) = \frac{1}{Z}\prod_{i=1}\prod_{j\in\mathcal{N}(i)} p(y_i|x_i)\,p_{i,j}(x_j|x_i)\,p(x_i)\,E(\mathbf{x})$$

Pair-wise Compatibility; Exclusivity term; Local evidence; Patch prior

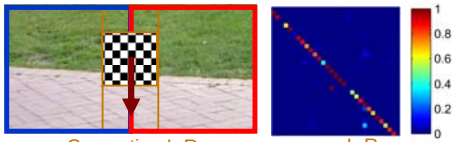
- Adjacent patches should plausibly fit next to each other.
- Each patch should not be used more than once (we name it the **exclusivity term**.)
- The image structure and user's constraints should be maintained.

The inverse patch transform



Belief propagation is used to solve for patch assignments

Pair-wise compatibility



Computing L-R natural image filter energy

L-R Compatibility

$$\psi^A_{i,j}(k,l) = \frac{1}{Z}\prod_{l,m}\sum_{q=1}^{J}\left\{\frac{\pi_q}{\sigma_q}exp(-w_l^T x_m(k,l))\right\}$$

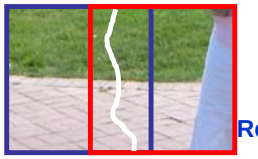
Exclusivity term

$$m_{fi}(x_i=l) \approx \prod_{t\in S\setminus i}\sum_{x_t=1}^{M}\psi_{F_t}(x_t|x_i=l)m_{tf}(x_t)$$
$$= \prod_{t\in S\setminus i}(1-m_{tf}(x_t=l))$$

The factor node tells others not to use the patch already claimed by another node.

Extensions

The patch transform using overlapping patches can reduce artifacts.



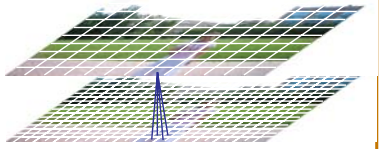
Seam-based compatibility measure

Remove

Object Removal

User input — Reconstructed image

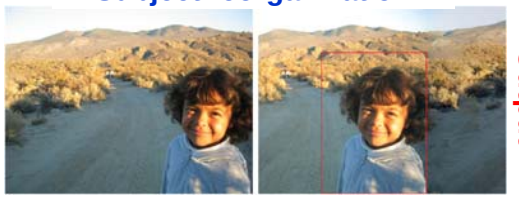
Multiscale Patch Transform



The reconstructed image using coarse patches is refined with smaller patches.

Image editing applications

Subject reorganization



Texture control

Image retargetting

Photomontage