Computer Vision for Visual Effects

CVFX 2015

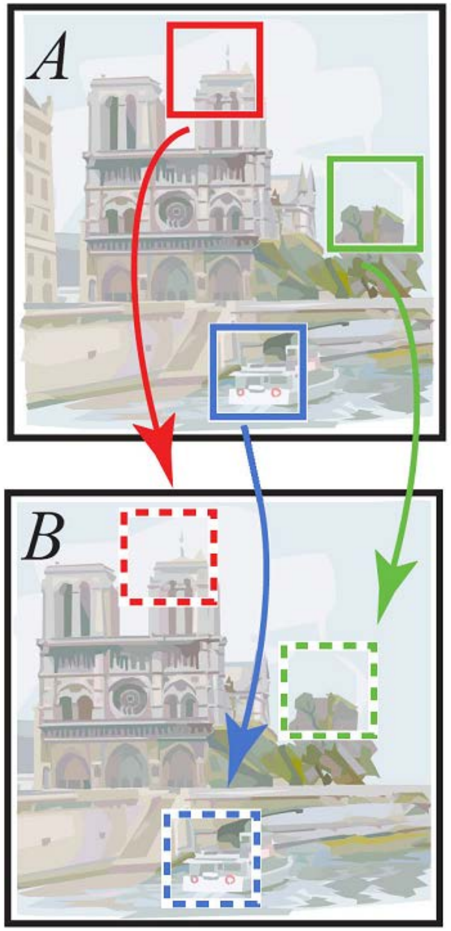
- *PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing*
  - Barnes *et al.*, SIGGRAPH 2009

Demo Video

PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing

- Key issue: how to search efficiently all patches in one image region for the most similar patch in another image region

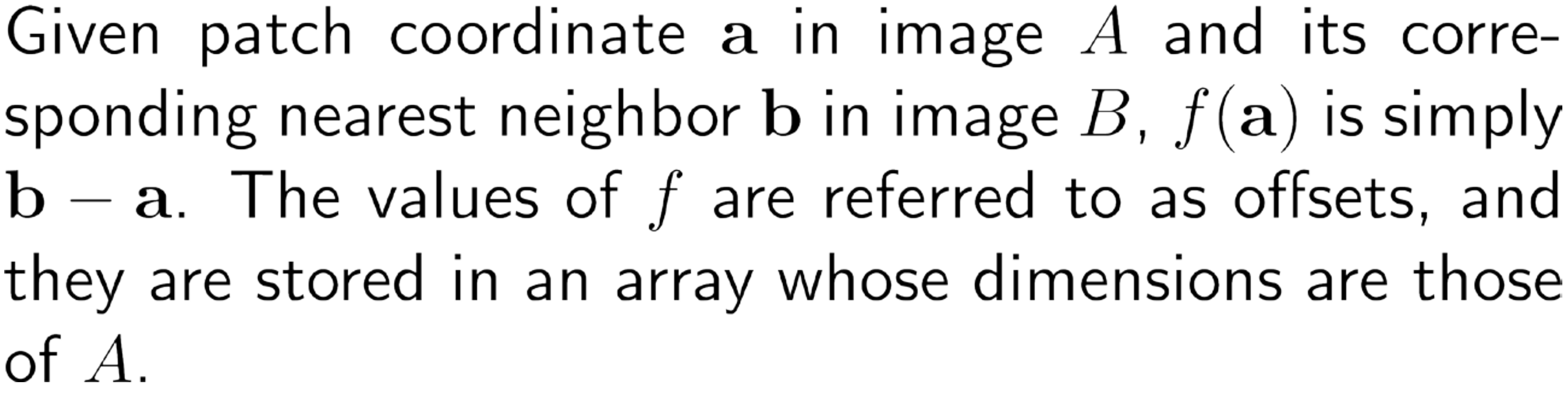
- Recall texture synthesis
  - Efros and Leung, ICCV 1999
  - Wei and Levoy, SIGGRAPH 2000



[Barnes *et al.]*

Nearest-Neighbor Field (NNF)

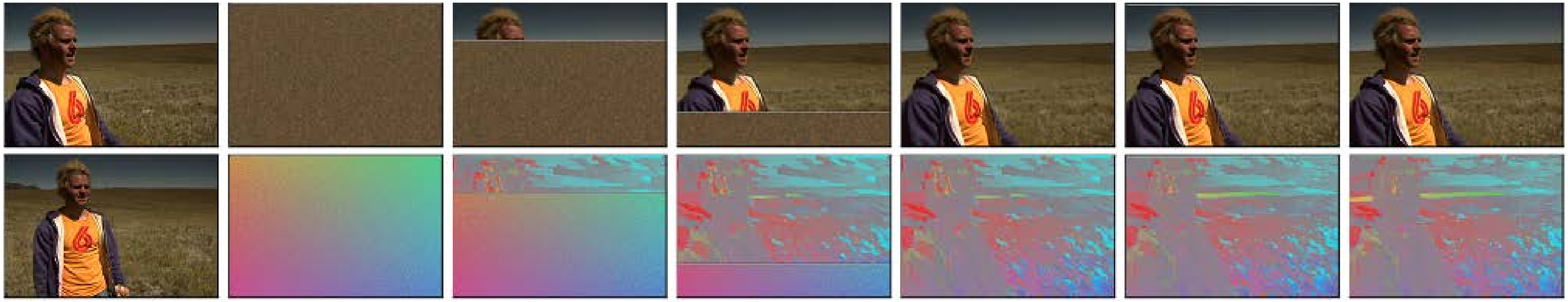
- A function of offsets $f : A \mapsto R^2$
- Defined over all possible patch coordinates in image A, for some distance function D of two patches.



Given patch coordinate $\mathbf{a}$ in image A and its corresponding nearest neighbor $\mathbf{b}$ in image B, $f(\mathbf{a})$ is simply $\mathbf{b} - \mathbf{a}$. The values of f are referred to as offsets, and they are stored in an array whose dimensions are those of A.

Cf. optical flow

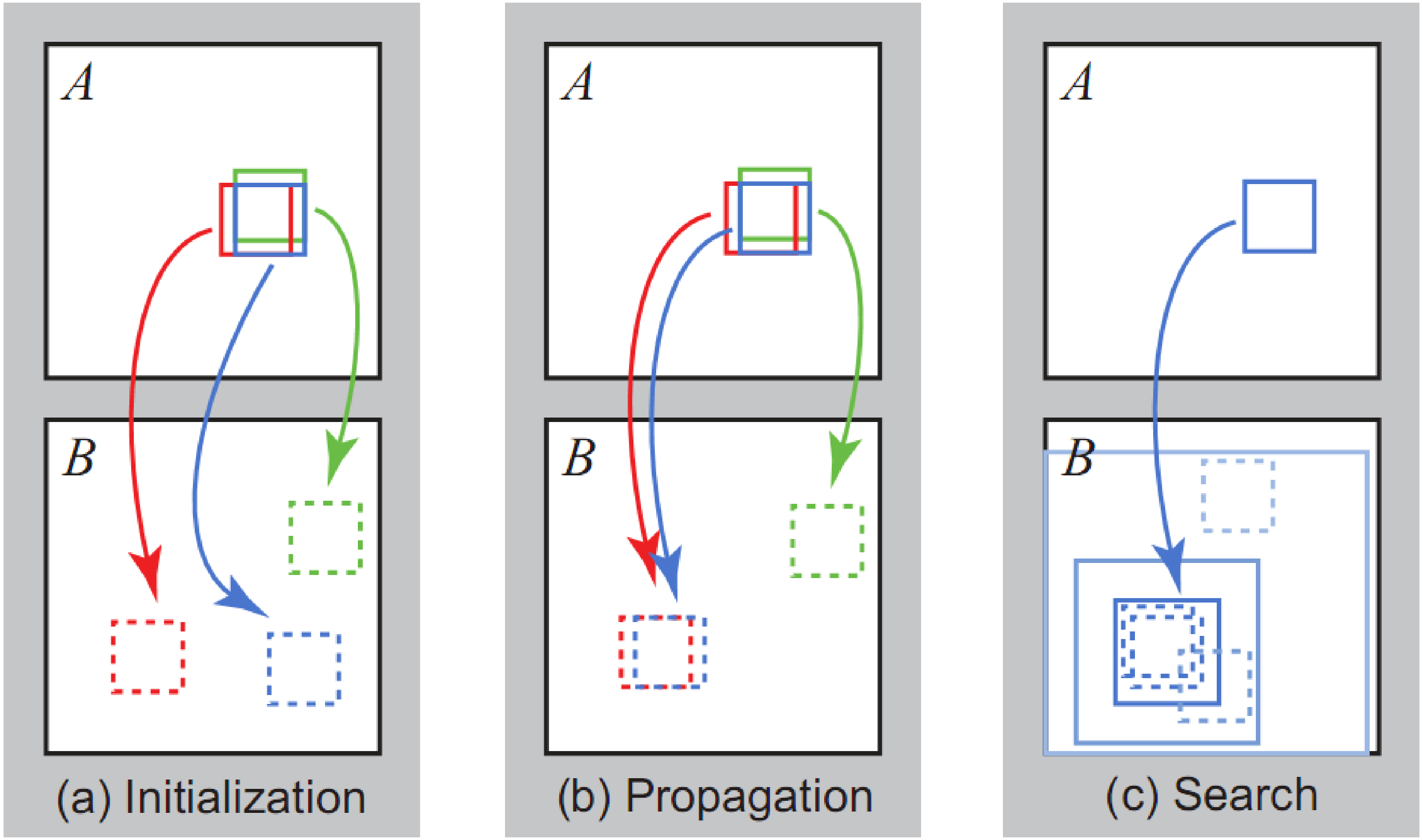
An Example of Offset Field



(a) originals (b) random (c) $\frac{1}{4}$ iteration (d) $\frac{3}{4}$ iteration (e) 1 iteration (f) 2 iterations (g) 5 iterations

Saturation → magnitude
Hue → angle

Approximate Nearest-Neighbor Field

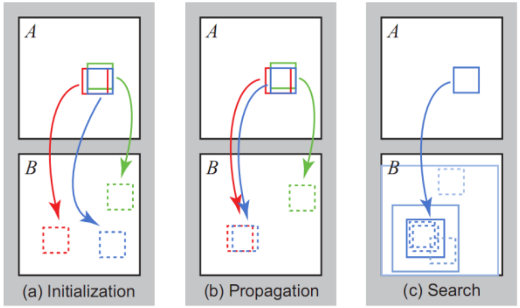


(a) Initialization

(b) Propagation

(c) Search

Approximate NNF Algorithm



- Initialization
  - Assign random values to the field
- Iteration (from left to right, top to bottom)
  - Propagation

$$f(x,y) = \arg\min\{D(f(x,y)), D(f(x-1,y)), D(f(x,y-1))\}$$

measure patch similarity

to copy the offset from neighbors

  - Random search

$$\mathbf{v}_0 = f(x,y)$$

$$\mathbf{u}_i = \mathbf{v}_0 + w\alpha^i\mathbf{R}_i$$

$\mathbf{R}_i$ is a uniform random in $[-1,1]\times[-1,1]$

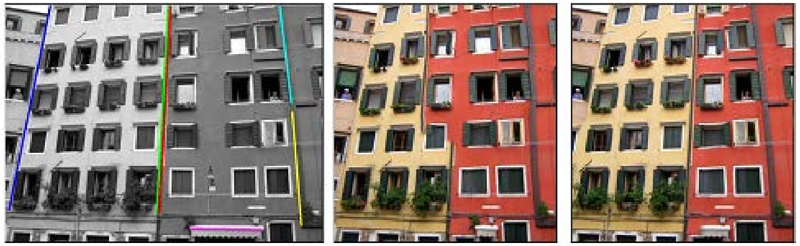
$w\alpha^i$ is a decaying search radius

Interactive Editing

- Bidirectional distance measure

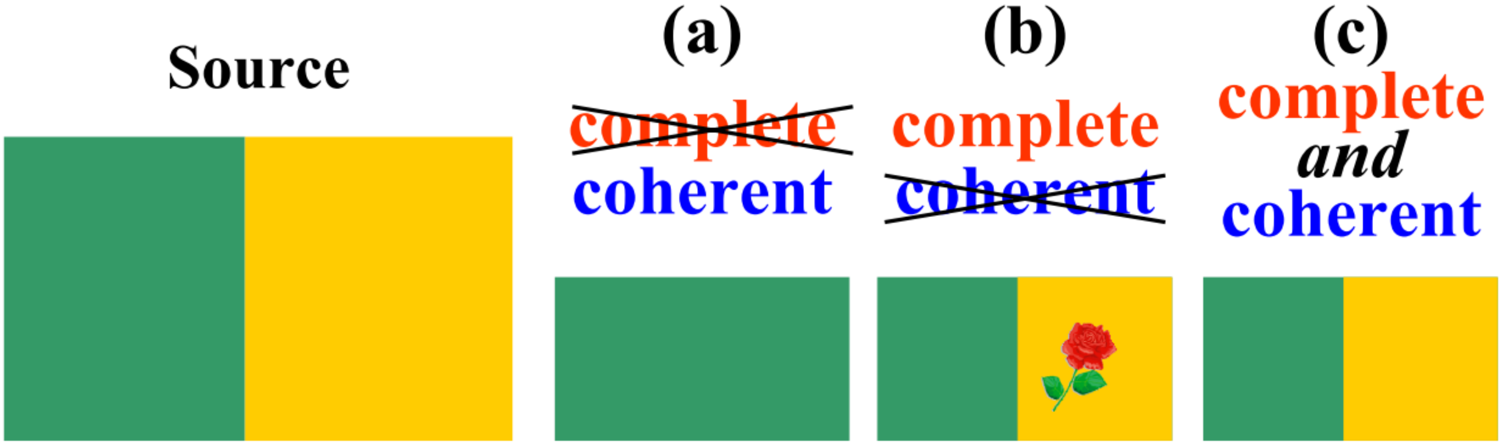
$$d_{BDS}(S,T) = \overbrace{\frac{1}{N_S}\sum_{s\subset S}\min_{t\subset T} D(s,t)}^{d_{complete}(S,T)} + \overbrace{\frac{1}{N_T}\sum_{t\subset T}\min_{s\subset S} D(t,s)}^{d_{cohere}(S,T)}$$

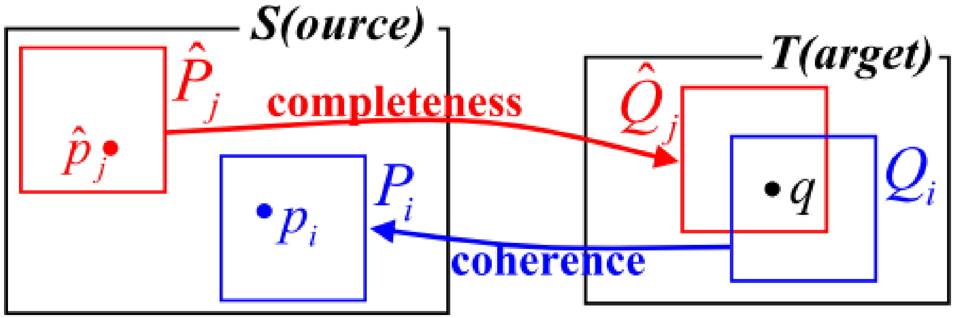
- Adding constraints
  - Search space constraints
  - Deformation constraints
    - » Model constraints



    - » Hard constraints (reshuffling, like "patch transform")

Bidirectional Similarity Measure


Source
(a)
~~complete~~
coherent
(b)
complete
~~coherent~~
(c)
complete
and
coherent


S(ource)
T(arget)
$\hat{P}_j$
$\hat{p}_j$
completeness
$\hat{Q}_j$
q
Q_i
P_i
p_i
coherence