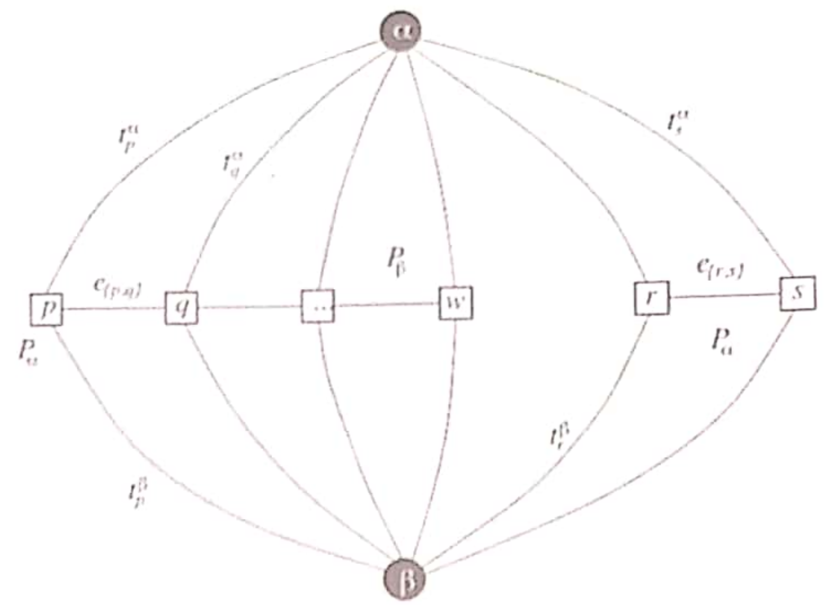
α–β swap move

```
1.   Start with an arbitrary labeling f
2.   Set success := 0
3.   For each pair of labels {α, β} ⊂ ℒ
     3.1.  Find f̂ = arg min E(f') among f' within
           one α-β swap of f (Section 3)
     3.2.  If E(f̂) < E(f), set f := f̂
           and success := 1
4.   If success = 1 goto 2
5.   Return f
```

α-β swap move

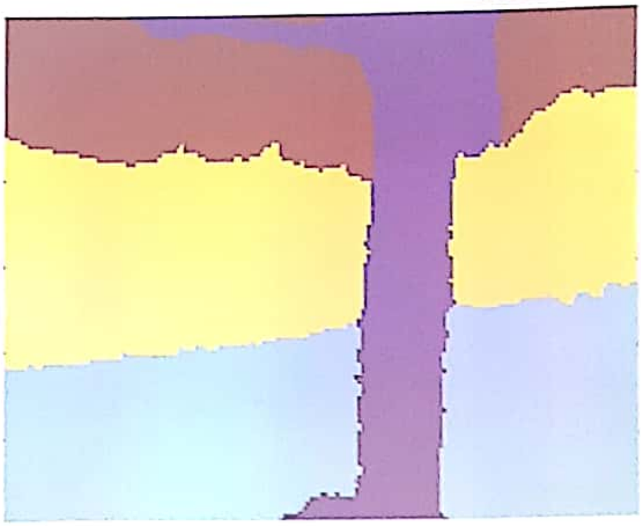


α−β swap move

Swap Sky, House

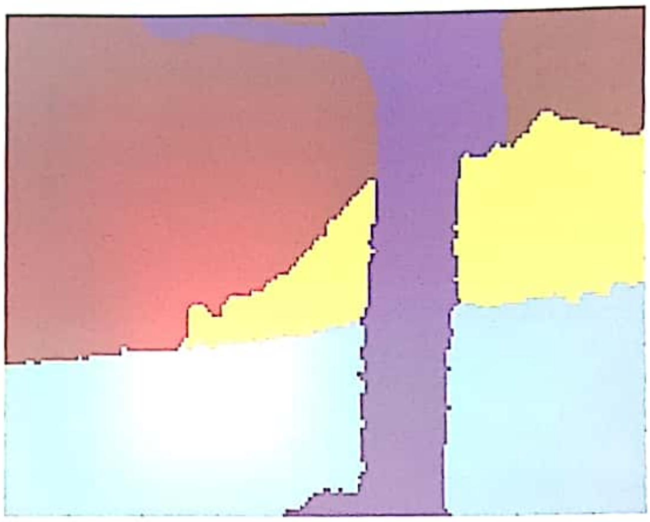
Tree
Ground
House
Sky

- Variables labeled α, β can swap their labels



α−β swap move

- Variables labeled α, β can swap their labels

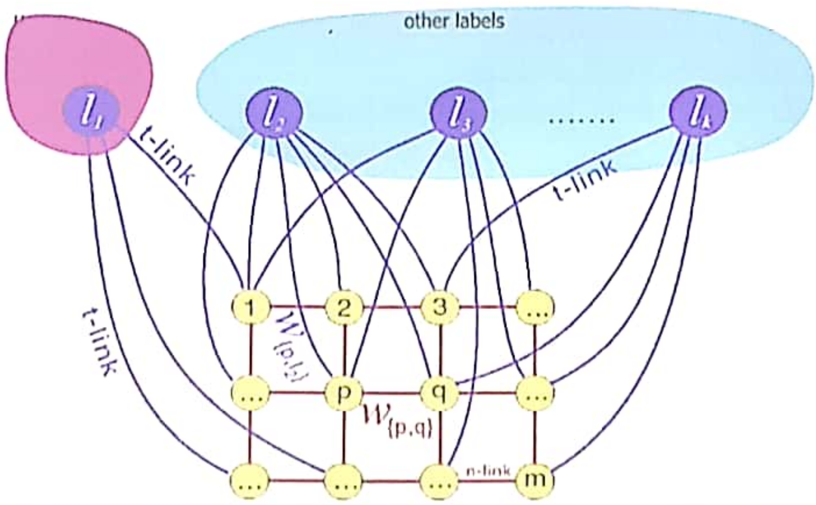


α-expansion Algorithm

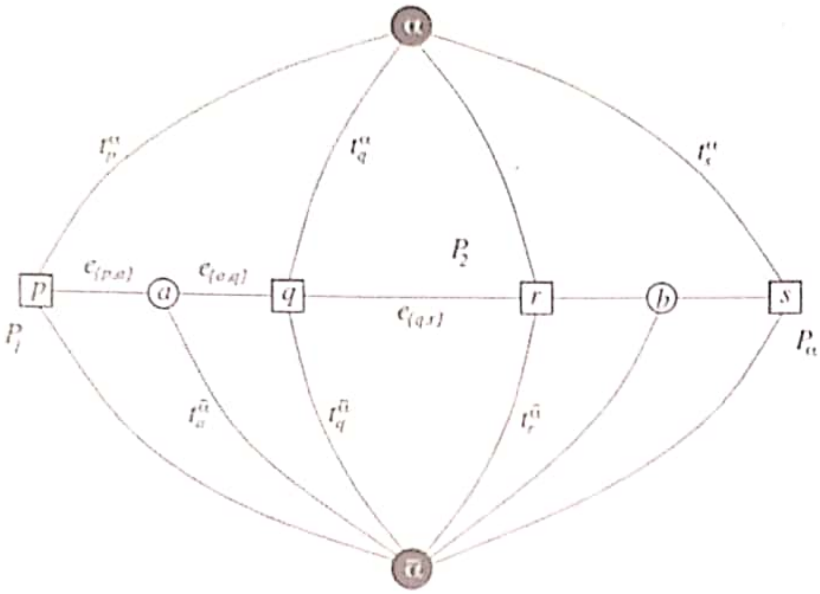
1. Start with an arbitrary labeling f
2. Set success := 0
3. For each label $\alpha \in \mathcal{L}$
   3.1. Find $\hat{f} = \arg\min E(f')$ among f' within one α-expansion of f (Section 4)
   3.2. If $E(\hat{f}) < E(f)$, set f := $\hat{f}$ and success := 1
4. If success = 1 goto 2
5. Return f

α−expansion Move

Basic idea: break multi-way cut computation into a **sequence of binary s-t cuts**

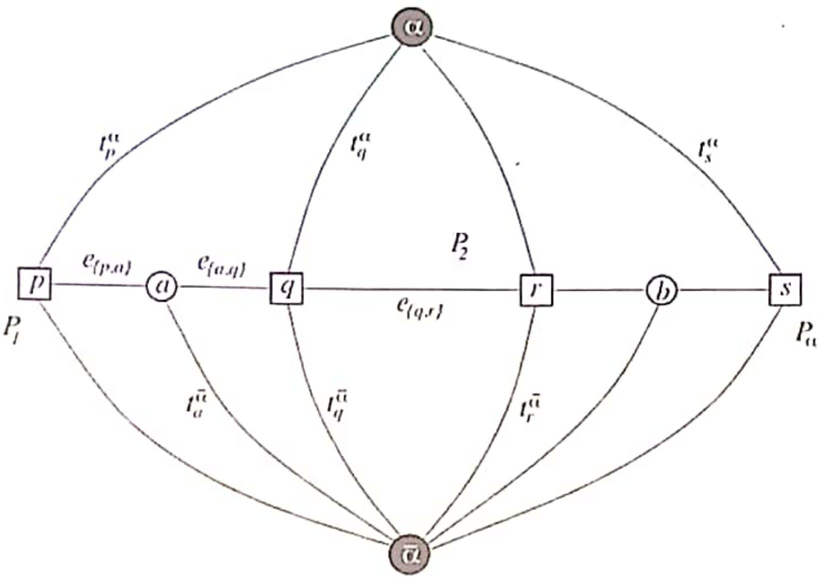


α-expansion Algorithm



edge	weight	for
t_p^{α}	∞	$p \in \mathcal{P}_\alpha$
$t_p^{\bar{\alpha}}$	$D_p(f_p)$	$p \notin \mathcal{P}_\alpha$
t_p^{α}	$D_p(\alpha)$	$p \in \mathcal{P}$
$e_{\{p,a\}}$	$V(f_p, \alpha)$	
$e_{\{a,q\}}$	$V(\alpha, f_q)$	$\{p,q\} \in \mathcal{N},\ f_p \neq f_q$
$t_a^{\bar{\alpha}}$	$V(f_p, f_q)$	
$e_{\{p,q\}}$	$V(f_p, \alpha)$	$\{p,q\} \in \mathcal{N},\ f_p = f_q$

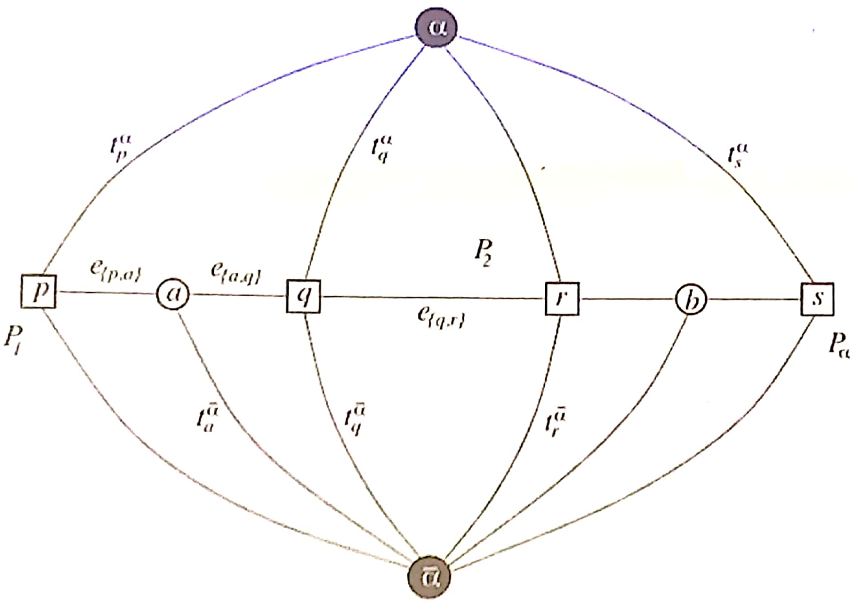
α-expansion Algorithm



edge	weight	for
$t_p^{\bar{\alpha}}$	∞	$p \in \mathcal{P}_\alpha$
$t_p^{\bar{\alpha}}$	$D_p(f_p)$	$p \notin \mathcal{P}_\alpha$
t_p^{α}	$D_p(\alpha)$	$p \in \mathcal{P}$
$e_{\{p,a\}}$	$V(f_p, \alpha)$	$\{p,q\} \in \mathcal{N},\ f_p \neq f_q$
$e_{\{a,q\}}$	$V(\alpha, f_q)$	
$t_a^{\bar{\alpha}}$	$V(f_p, f_q)$	
$e_{\{p,q\}}$	$V(f_p, \alpha)$	$\{p,q\} \in \mathcal{N},\ f_p = f_q$

Scanned by CamScanner

α-expansion Algorithm



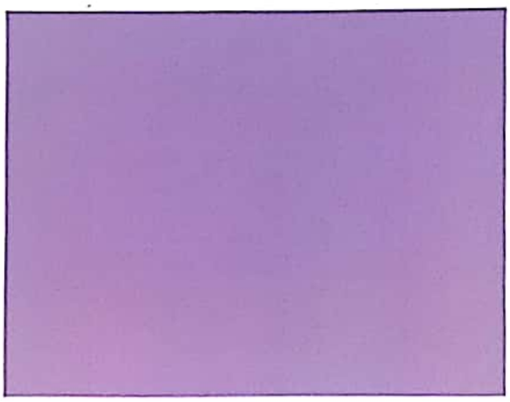
edge	weight	for
$t_p^{\bar{\alpha}}$	∞	$p \in \mathcal{P}_\alpha$
$t_p^{\bar{\alpha}}$	$D_p(f_p)$	$p \notin \mathcal{P}_\alpha$
t_p^{α}	$D_p(\alpha)$	$p \in \mathcal{P}$
$e_{\{p,a\}}$	$V(f_p, \alpha)$	$\{p,q\} \in \mathcal{N},\ f_p \neq f_q$
$e_{\{a,q\}}$	$V(\alpha, f_q)$	
$t_a^{\bar{\alpha}}$	$V(f_p, f_q)$	
$e_{\{p,q\}}$	$V(f_p, \alpha)$	$\{p,q\} \in \mathcal{N},\ f_p = f_q$

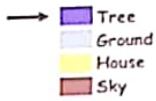
α-expansion Move

In each α-expansion a given label "α" grabs space from other labels

Image Segmentation

Status: Initialize with Tree



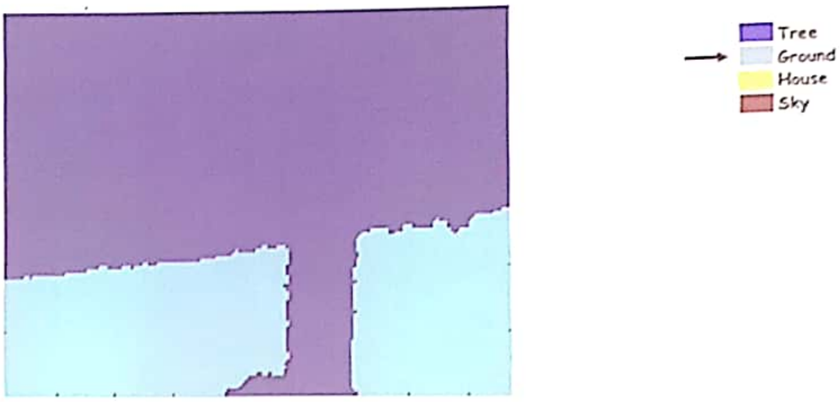


α-expansion Move

In each α-expansion a given label "α" grabs space from other labels

Image Segmentation

Status: Expand Ground

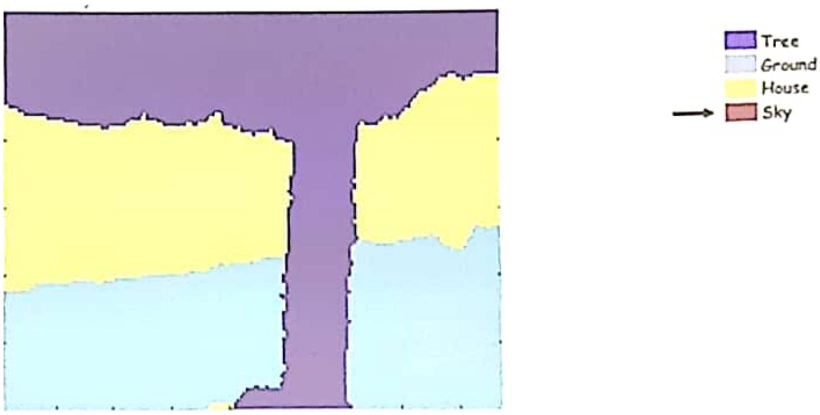


α–expansion Move

In each α-expansion a given label "α" grabs space from other labels

Image Segmentation

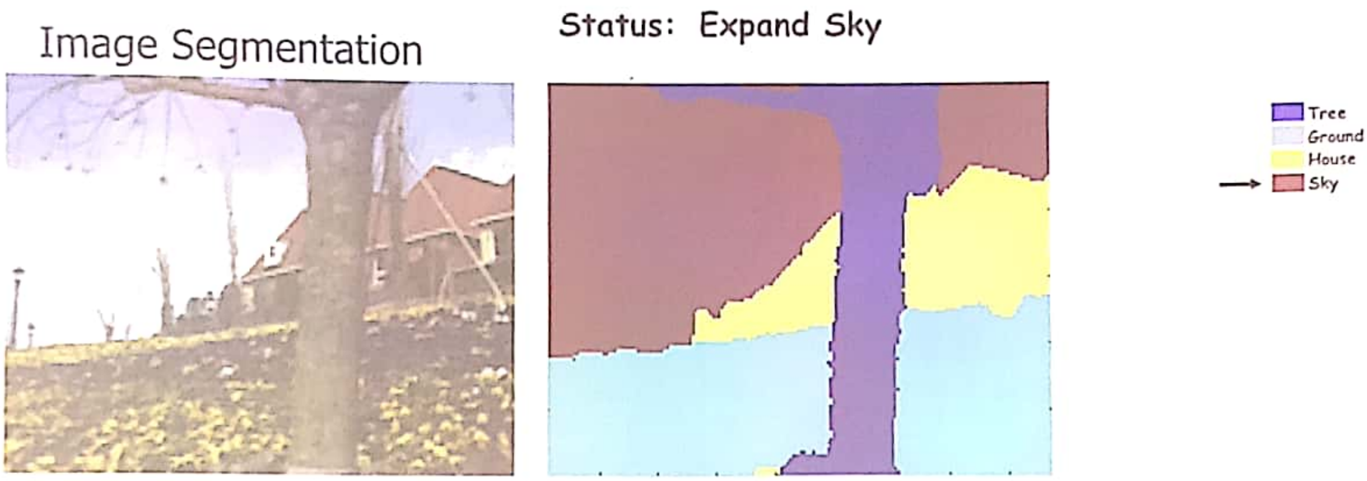
Status: Expand Sky



α-expansion Move

In each α-expansion a given label "α" grabs space from other labels

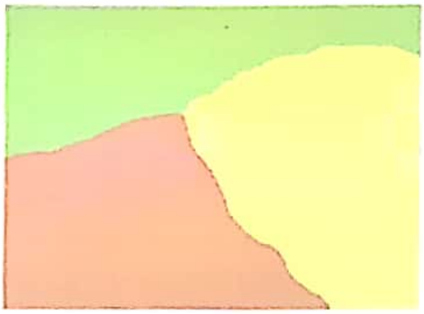
Image Segmentation



α–expansion Move

In each α-expansion a given label "α" grabs space from other labels

Stereo



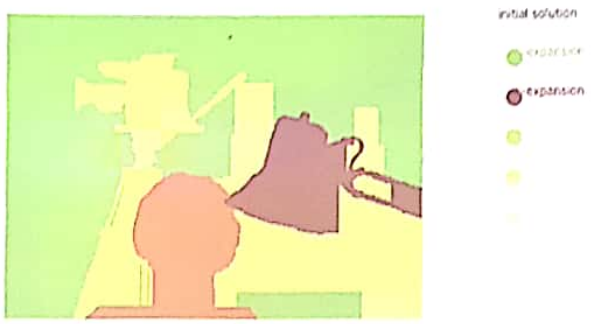
initial solution

For each move we choose expansion that gives the largest decrease in the energy: **binary optimization problem**

α–expansion Move

In each α-expansion a given label "α" grabs space from other labels

Stereo



For each move we choose expansion that gives the largest decrease in the energy: **binary optimization problem**

Ink-Bleed Removal

Yi Huang Michael S. Brown Dong Xu
"A Framework for Reducing Ink-Bleed in Old Documents",
Proc. CVPR, June 2008, Anchorage, AK, USA.

What is Ink-Bleed ?

- Ink bloats through paper and appears on the reverse side

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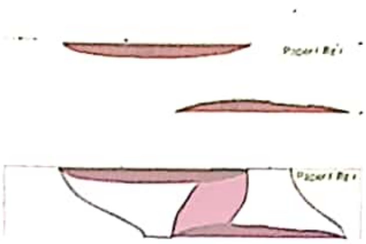
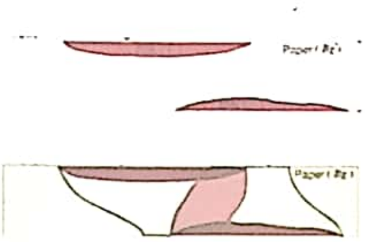
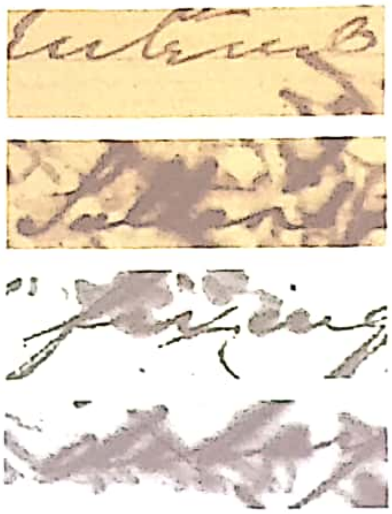


What is Ink-Bleed ?

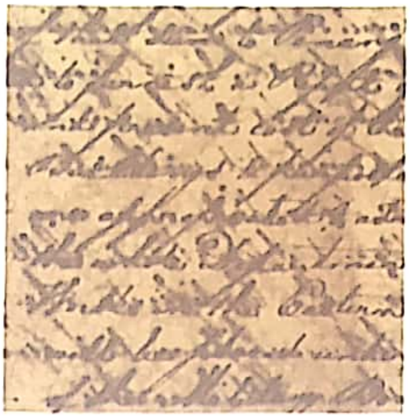
- Ink bloats through paper and appears on the reverse side



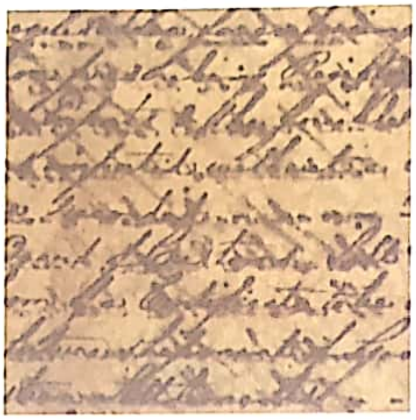


Recto and Verso Images

Recto (front) Side



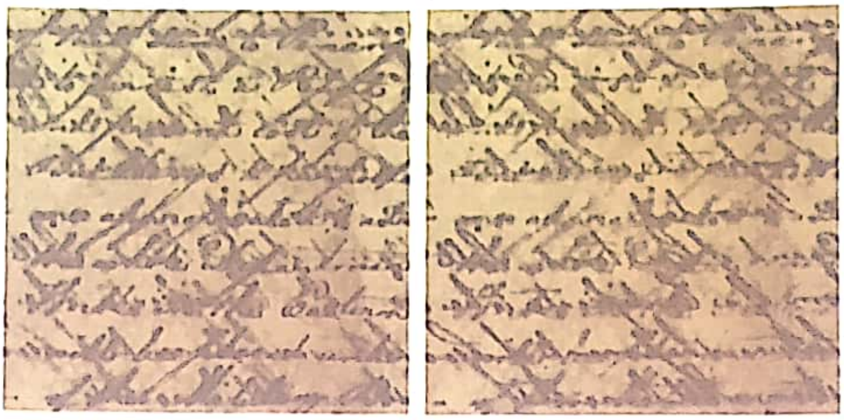
Verso (back) Side



Recto and Verso Images

Recto (front) Side ⇔ Verso (back) Side

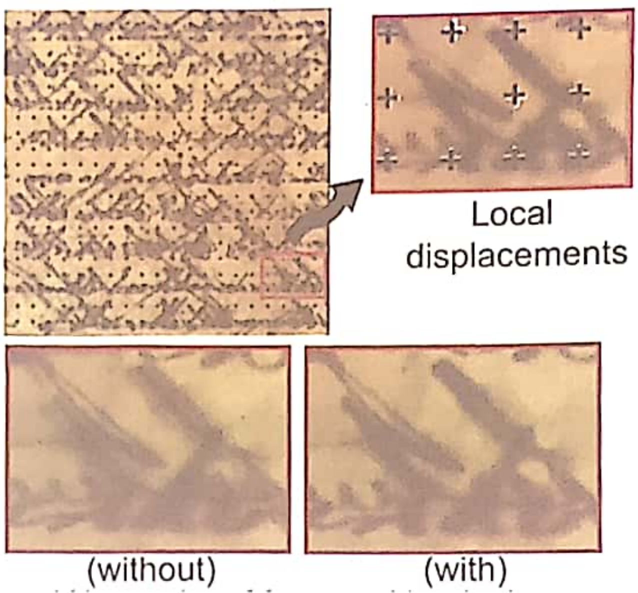
Recto and Verso Images



- Treat the two restoration problems together

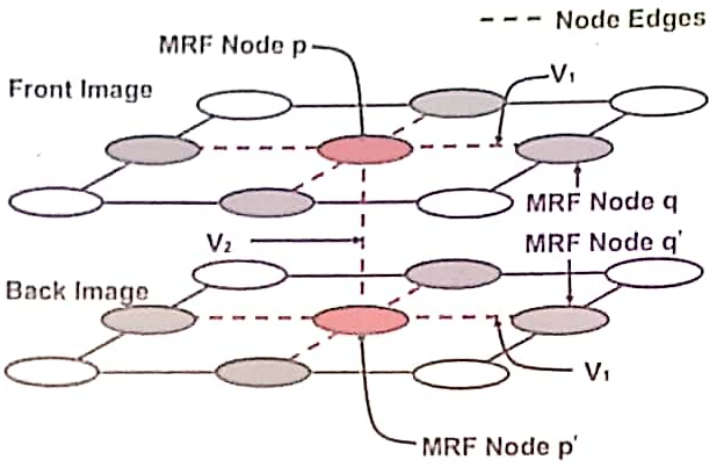
Local Alignment

- Compute correlations at a set of grid points: 60x60 patch; [-10,10] displacement
- Smoothen the local displacements using thin-plate-spline (TPS) interpolation
- Warp the verso image



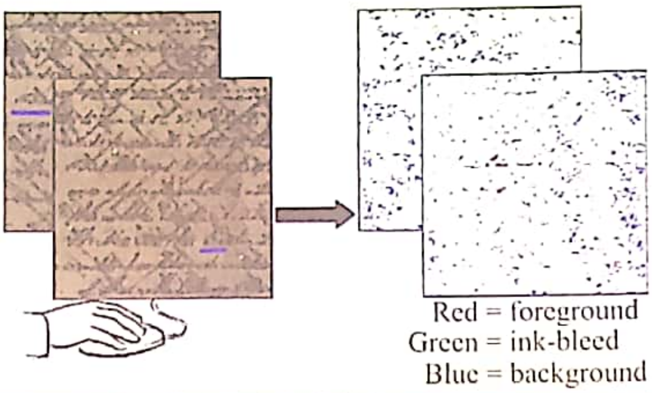
Dual Layer MRF

- Consider two sets of nodes, one for recto and one for verso
- The pixels/nodes of the images are aligned
- Connect corresponding pixels from either side.



Features and Training Input

- Intensity Features C_p and $C_{p'}$
- Ratio Features $\rho_p = \dfrac{C_p}{C_{p'}}$
- Training Input



Defining Potentials

- Data Cost Energy Modeling
  - Ratio feature is normalized (zero mean with and unit standard deviation)
  - These normalised features are clustered with K means to obtain cluster centres for each of the three classes as:

$$\{\rho_i^{\mathcal{F}}\}|_{i=1}^{L}, \{\rho_j^{\mathcal{I}}\}|_{j=1}^{M} \text{ and } \{\rho_k^{\mathcal{B}}\}|_{k=1}^{N}$$

  - For each pixel p, we compute the Euclidean distances (L2-norm) between ρ_p and all the L + M + N cluster centres and then select top-K closest ones.
  - These top-K centers are denoted as $\{\rho_m\}|_{m=1}^{K}$ and are further divided into three index sets πF ,πI and πB according to their labels.
  - The distance between ρ_p and the m-th cluster center ρm is computed by:

$$d_{pm} = ||\rho_p - \rho_m||$$

Defining Potentials

- Class Similarity:

$$
\begin{aligned}
S_{\mathcal{F}} &= \sum_{m \in \pi^{\mathcal{F}}} \exp(-d_{pm}^2 / d_p^2) \\
S_{\mathcal{I}} &= \sum_{m \in \pi^{\mathcal{I}}} \exp(-d_{pm}^2 / d_p^2) \\
S_{\mathcal{B}} &= \sum_{m \in \pi^{\mathcal{B}}} \exp(-d_{pm}^2 / d_p^2).
\end{aligned}
$$

- Unary:

$$
\begin{aligned}
E_d(l_p = \mathcal{F}) &= \frac{S_{\mathcal{I}} + S_{\mathcal{B}}}{2 \times (S_{\mathcal{F}} + S_{\mathcal{I}} + S_{\mathcal{B}})} \\
E_d(l_p = \mathcal{I}) &= \frac{S_{\mathcal{F}} + S_{\mathcal{B}}}{2 \times (S_{\mathcal{F}} + S_{\mathcal{I}} + S_{\mathcal{B}})} \\
E_d(l_p = \mathcal{B}) &= \frac{S_{\mathcal{F}} + S_{\mathcal{I}}}{2 \times (S_{\mathcal{F}} + S_{\mathcal{I}} + S_{\mathcal{B}})}.
\end{aligned}
$$

Defining Potentials

- Pairwise: $$E_s = \sum_{p,q \in \mathcal{N}} V_1(l_p, l_q) + \sum_{p,p' \in \mathcal{M}} V_2(l_p, l_{p'})$$

- Intra-Layer: $$V_1(l_p, l_q) = \frac{1}{1 + (\xi_{pq})^2} \qquad d^{\rho}_{pq} = ||\rho_p - \rho_q||$$

l_p	l_q Foreground	Ink-Bleed	Background
Foreground	∞	d^{ρ}_{pq}	d^{c}_{pq}
Ink-Bleed	d^{ρ}_{pq}	∞	d^{ρ}_{pq}
Background	d^{c}_{pq}	d^{ρ}_{pq}	∞

Defining Potentials

- Pairwise: $$E_s = \sum_{p,q \in \mathcal{N}} V_1(l_p, l_q) + \sum_{p,p' \in \mathcal{M}} V_2(l_p, l_{p'})$$

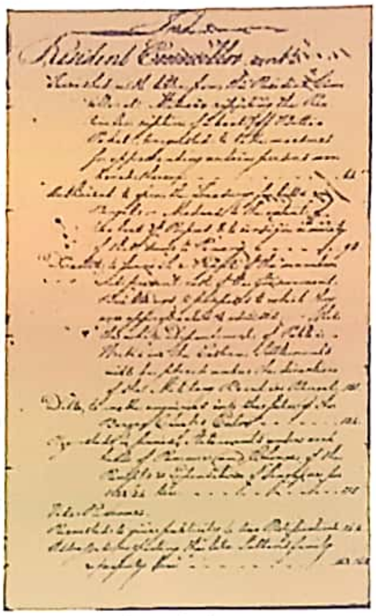
- Intra-Layer: $$V_1(l_p, l_q) = \frac{1}{1 + (\xi_{pq})^2} \qquad d^{\rho}_{pq} = ||\rho_p - \rho_q||$$

l_p	l_q		
	Foreground	Ink-Bleed	Background
Foreground	∞	d^{ρ}_{pq}	d^{c}_{pq}
Ink-Bleed	d^{ρ}_{pq}	∞	d^{ρ}_{pq}
Background	d^{c}_{pq}	d^{ρ}_{pq}	∞

- Inter-Layer: $$V_2(l_p, l_{p'})$$

l_p	$l_{p'}$		
	Foreground	Ink-Bleed	Background
Foreground	0	0	0
Ink-Bleed	0	∞	∞
Background	0	∞	2ω

Front•Markup



Corrected

Results: Comparison

A Closer Look