Problem and Formulation

- Non-uniform blur by camera shake (rotation and translation)

Model the blurred input $B$ as the integration of intermediate images $f(L, \theta)$ (transformed copies of the sharp image) captured at different poses $\theta$ of a motion trajectory [Whyte CVPR10]

$$B = \sum_{\theta \in S} f(L, \theta) w_\theta + n = \sum_{\theta \in S} w_\theta K_\theta L + n$$  \hspace{1cm} (1)

$w(\theta)$: exposure time at each pose
$K_\theta$: matrix that warps latent image $L$ to the transformed copy
$S$: camera pose space

Optimization problem for non-uniform deblur and solve the problem in an alternating way

$$\min_{(L, W)} \left\| \sum_{\theta \in S} w_\theta K_\theta L - B \right\|^2 + \Phi_1(L) + \Phi_2(W)$$  \hspace{1cm} (2)

$\Phi_1, \Phi_2$: regularization terms on $L$ and $W$

Main Challenges

- Lack of good initialization technique of camera motion
  good initialization: avoid numerous local minimum; fast convergence
- High computational load

Execution time of a 441x611 image

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>Whyte CVPR10</td>
<td>about 3 hours</td>
</tr>
<tr>
<td>Gupta ECCV10</td>
<td>about 1 hour</td>
</tr>
<tr>
<td>Hirsch ICCV11</td>
<td>about 25 mins</td>
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</tbody>
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Algorithm

- Motivated by backprojection in image processing
  reconstruct 2D signal from its 1D projections

- Backproject local PSFs to the camera motion
  reconstruct 3D camera motion from 2D PSFs

Motion Estimation on Constrained Pose Subspace

How to determine the active set?

- Initialize $A$ by thresholding the backprojected camera motion
- At each iteration, discard the poses with small weights and add in poses by sampling
- Sampling based on the previous $A$ using a Gaussian distribution

Experimental Results

- MATLAB implementation: 10 mins to process a 441x611 image
- Results and code are available on http://eng.ucmerced.edu/people/zhu/