Tree-Structured Algorithm For Efficient Shearlet-domain Light Field Reconstruction

Suren Vagharshakyan, Robert Bregovic, Atanas Gotchev

Department of Signal Processing, Tampere University of Technology, Tampere, Finland
Outline

• Problem formulation
  – Light Field reconstruction algorithm in epipolar-plane image domain using shearlet transform

• Two tree-structured algorithms for acceleration of the reconstruction utilizing epipolar images’ similarity.

• Reconstruction results and evaluation
Problem Formulation
Light Field Reconstruction
Epipolar-plane image

Densely sampled  Coarsely sampled

Spatial domain  Frequency domain  Spatial domain  Frequency domain

\[ \Delta d_{\text{max}} = \frac{f}{z_{\text{min}}} \Delta t \leq 1 \]
Discrete Shearlet Transform

Disparity based frequency domain separation

Spatial domain

Frequency domain
EPI Reconstruction Algorithm

$g$ - measured incomplete data
$H$ - corresponding mask of known samples
$S, S^*$ - shearlet analysis and synthesis transforms

Iterative Hard Thresholding

$$f_{n+1} = S^* \left( H_{\lambda_n} \left( S(f_n + \alpha (g - Hf_n)) \right) \right)$$

$$H_{\lambda}(x) = \begin{cases} x, & |x| \geq \lambda \\ 0, & |x| < \lambda \end{cases}$$

Hard thresholding operator

$$\lambda_n = (\lambda_{\text{max}} - \lambda_{\text{min}}) \frac{n}{L} + \lambda_{\text{min}}$$

Iteratively decreasing threshold

$g = Hf^*$ and $S(f^*)$ is sparse
EPI Reconstruction Algorithm

Initial epipolar image

Replace measured data

2D Fourier Transform(s)

Analysis

2D Inverse Fourier Transform(s)

Hard Thresholding by \( \lambda_n \)

Synthesis

2D Fourier Transform(s)

2D Inverse Fourier Transform(s)

Reconstructed epipolar image

\( n = n + 1 \)

\( n < N \)

Yes

No
$\alpha$ parameter selection

![Graph showing PSNR (dB) against iteration for different values of $\alpha$. The graph has a legend indicating $\alpha = 5$, $\alpha = 10$, $\alpha = 20$, and $\alpha = 30$.](image)
Initial estimation distance

PSNR (db) vs Iteration for different values: 225.2, 345.8, 432.4
Reconstruction order

- Independent reconstruction of EPIs is highly parallelizable
- For given set of view in which order to process EPI reconstruction algorithm to utilize similarity between EPIs and still keep independent processing for given M processing units?
- Construct tree-structured processing order to utilize either similarity between EPIs or number of given processing units
Algorithm I
Algorithm II
Reconstruction Results

Ground Truth

Independent reconstruction

Algorithm I

Algorithm II
Acceleration

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<th>PSNR (dB)</th>
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<td>22.4</td>
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- **Algorithm I**
  - Red channel: 0.622
  - Green channel: 0.652
  - Blue channel: 0.652

- **Algorithm II**
  - Red channel: 0.758
  - Green channel: 0.782
  - Blue channel: 0.774
Summary

- Presented two tree-structured processing algorithms for accelerating LF reconstruction
  - Algorithm I is optimized for maximizing usage of similarity between EPIs
  - Algorithm II is optimized for using M-node paralyzed computation as well as taking into account similarity between EPIs
- For both algorithms, there is a negligible difference between reconstruction results with significantly decreased computation time