SUPER RESOLUTION WITH BETTER EDGE ENHANCEMENT

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Committee Members
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• Introduction of image super-resolution (SR).
• Related works
• Proposed SR framework
• Image quality assessment
• Experimental Results
• Conclusion
• Future work
• References
Introduction of Image Super-resolution
What is resolution?

- Optical resolution
- Image resolution

Super-resolution

- Low resolution (LR) → High resolution (HR)
Significance of SR

- More detail the information contained in image.
- Image resolution is directly proportional to optical resolution.
- Ways to increase the image resolution:
  - Reduce the size of sensing elements
  - Increase the wafer size.
• Surveillance video
• Remote sensing
• Medical imaging (CT, MRI, ultrasound, etc.)
• Video standards conversion, e.g., from NTSC video signal to HDTV signal
• Astronomical imaging
• Target detection and recognition
Related work

- Approaches to super-resolution:
  1. Interpolation based.
  2. Reconstruction based.
  3. Learning based.
Proposed SR Framework
Super-resolution with better edge enhancement
Bilateral Filtering

- Traditional filters (like Gaussian filter) implement only in domain.
- Bilateral filter gets also applied in range of an image.
- Closeness $\rightarrow$ Domain
- Similarity $\rightarrow$ Range
Bilateral Filtering

- Domain filtering: weigh pixel values with distance.
- Range filtering: averages image values with weights that decay with dissimilarity.
- Range filters are non-linear.
- Hence preserve edges.
- Combination of both range and domain filtering is denoted as bilateral filtering.
Super-resolution with better edge enhancement
Super-resolution with better edge enhancement
Mean Shift Image Segmentation

- Decomposition of image into homogeneous tiles.
- Takes advantage of mean shift filtering.
- Works in joint domain i.e. spatial-range domain.
Mean Shift Image Segmentation

- Pixels
  - Spatial location
  - Color/grayscale intensity

- For this pixel a set of neighboring is determined.
- New spatial mean and grayscale mean calculated that serves new center for the next iteration.
- At the end, final mean color will be assigned to the starting position.
Super-resolution with better edge enhancement
Shock filter

- Creates strong discontinuities at image edges.
- The filtered signal within a region delineated by those edges becomes flat.
- Satisfies the maximum -minimum principle [26].
- No appearance of Gibbs phenomenon [27].
Super-resolution with better edge enhancement
• Idea: The reconstructed HR image from the degraded LR image should produce the same observed LR image if passing it through the same blurring and downsampling process.
IBP Process

- Start with initial guess of HR image.
- Simulate a LR image based on this HR image.
- Compare this LR image with the original LR image.
- Propagate or back-project this error onto the initial guessed HR image.
- Iterate this process until the error is minimized.
Super-resolution with better edge enhancement
Significance of initial guess in IBP
Similar Structure Learning

- Two criterions used for structure learning:
  - Zero mean normalized cross correlation (ZNCC).
  - Mean absolute difference (MAD)
- ZNCC emphasizes the similarity of the structural or geometrical content.
- MAD underlines the similarity of the luminance (and color) information.
- If $\text{ZNCC} > \tau_{\text{ZNCC}}$ and $\text{MAD} < \tau_{\text{MAD}} \rightarrow$ Matching block.
Image Quality Assessment (IQA)
Metrics used

- Peak signal-to-noise ratio (PSNR)
- Structural SIMilarity index (SSIM)
- Feature SIMilarity index (FSIM)
  - Human Visual System (HVS) is sensitive low-level features, such as edges and zero crossings.
  - A good IQA metric should compare the low-level feature sets between the reference image and the distorted image.
Experimental Results
Test Images

- Lena
- Clock
- Barche
- Estatua
- Portofino

Super-resolution with better edge enhancement
Comparison using Lena image

<table>
<thead>
<tr>
<th>Algorithms</th>
<th>PSNR (dB)</th>
<th>SSIM</th>
<th>FSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed algorithm</td>
<td>28.91</td>
<td>0.9106</td>
<td>0.9518</td>
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<tr>
<td>Bicubic interpolation</td>
<td>28.27</td>
<td>0.8631</td>
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<td>POCS</td>
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<td>NLIBP</td>
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<td>2D auto regressive model</td>
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Super-resolution with better edge enhancement
Comparison using Barche image

<table>
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<th>PSNR (dB)</th>
<th>SSIM</th>
<th>FSIM</th>
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</thead>
<tbody>
<tr>
<td>Proposed algorithm</td>
<td>29.24</td>
<td>0.8913</td>
<td>0.9243</td>
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<tr>
<td>Bicubic interpolation</td>
<td>26.98</td>
<td>0.9331</td>
<td>0.9077</td>
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<tr>
<td>POCS</td>
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<td>0.6372</td>
<td>0.7567</td>
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<tr>
<td>NLIBP</td>
<td>27.46</td>
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<td>0.8403</td>
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![Bar chart showing comparison of SSIM and FSIM for different algorithms]

- SSIM
- FSIM

11/19/2012 Super-resolution with better edge enhancement
Comparison using Estatua image

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<tbody>
<tr>
<td>Proposed algorithm</td>
<td>30.19</td>
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Super-resolution with better edge enhancement
## Comparison using Portofino image

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<th>FSIM</th>
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<tr>
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![Graph with bar chart showing comparison of algorithms]
### Comparison using Clock image

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<th>SSIM</th>
<th>FSIM</th>
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</thead>
<tbody>
<tr>
<td>Proposed algorithm</td>
<td>29.19</td>
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<td>0.9379</td>
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</table>

![Bar chart comparing different algorithms based on PSNR, SSIM, and FSIM metrics.]
Conclusion

- 3-6% increase in the FSIM index.
- The proposed algorithm out-perform the other existing techniques when the image scene under consideration has more details (complex) in it. E.g. portofino, estatua and even barche.
Future Work
Super-resolution with better edge enhancement
References


Questions??