Multi-Laplacian GAN with Edge Enhancement for Face Super Resolution
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Abstract
Face image super-resolution has become a research hotspot in the field of image processing. Nowadays, more and more researches add additional information, such as landmark, identity, to reconstruct high resolution images from low resolution ones, and have a good performance in quantitative terms and perceptual quality. However, these additional information is hard to obtain in many cases. In this work, we focus on reconstructing face images by extracting useful information from face images directly rather than using additional information. By observing edge information in each scale of face images, we propose a method to reconstruct high resolution face images with enhanced edge information. In additional, with the proposed training procedure, our method reconstructs photorealistic images in upsampling factor 8x and outperforms state-of-the-art methods both in quantitative terms and perceptual quality.

Methods
The architecture of our edge enhancement upsampling network. The purpose of this paper is to extract edge information from images directly to reconstruct high resolution face images. To enhance edge information for reconstructing high resolution images effectively, we proposed a GAN architecture which is named as multi-Laplacian GAN with edge enhancement and abbreviated as MLGE. MLGE consists of two branches. The first one is the generative branch which upsamples low resolution images to multiscale (2x, 4x, 8x) ones. The second one is the discriminative branch which consists of a general discriminator and two edge discriminators.

Quantitative Comparison
<table>
<thead>
<tr>
<th>Method</th>
<th>Bicubic</th>
<th>VDSR</th>
<th>SRGAN</th>
<th>Yu et al.</th>
<th>MLGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSNR</td>
<td>21.76</td>
<td>23.12</td>
<td>23.76</td>
<td>22.85</td>
<td>25.07</td>
</tr>
<tr>
<td>SSIM</td>
<td>0.72</td>
<td>0.80</td>
<td>0.78</td>
<td>0.753</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Two popular metrics, including the average Peak Signal to Noise Ratio (PSNR) and the structural similarity (SSIM) scores are used as our quantitative metrics. Our method outperforms the second best with a large margin of 1.95 dB in PSNR. Based on the design of multiple pixel-wise losses and edge information enhancement, MLGE has the best performance of PSNR and SSIM and is able to reconstruct HR images both in face regions and non-face regions effectively.

Qualitative Comparison
Our method MLGE generally produces better looking and sharper face images than the state-of-the-art methods. Note that our method MLGE, which only uses 22K training images in this experiment, not only effectively reconstructs face regions but also non-face regions, such as the background region of the fifth row.

CONCLUSION AND FUTURE WORK
We proposed the multi-Laplacian GAN with edge enhancement (MLGE) model to reconstruct 128 × 128 HR face images from 16 × 16 pixel LR face images. MLGE reconstructed HR face images efficiently and no additional prior facial information is required in both training and testing phases. In future work, we will try to explore better information extracting methods from images and apply extracted information to reconstruct HR images effectively. Moreover, MLGE is possible to be extended to reconstruct all SR tasks.