Edge-aware Context Encoder for Image Inpainting

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Introduction

We present edge-aware context encoder (E-CE): an image inpainting model which takes scene structure and context into account. Unlike previous CE which predicts the missing regions using context from entire image, E-CE learns to recover the texture according to edge structures, attempting to avoid context blending across boundaries. In our approach, edges are extracted from the masked image, and completed by a full-convolutional network. The completed edge map together with the original masked image are then input into the modified CE network to predict the missing region. The experiments demonstrate that E-CE can generate images with better shapes and structures than CE. Our contributions are three-fold:

1) we demonstrate how structures can be employed for image inpainting and its effectiveness; 2) we develop a edge completion network to allow the prediction of context structures; 3) we develop a inpainting network to fill in textures according the high level structure constraints and the low level texture constraints.

Edge-aware Image Inpainting Strategy

Problem analysis

Context Encoder (CE) [1] has shown promise as prediction model of high-level context for completing images with large holes. While natural images contain composite structures and textures, and the textures are usually regions with homogenous patterns bounded by structures. Uniformed processing the results in clutter structures and mixing textures (Figure 1 (b)).

Structure has been proven to have high representation ability for the context. On one hand, compared to images with high frequency textures, the structure serves as a very good low dimensional embedding for scene context, which might be easier to complete than the original image. On the other hand, the structure is a good constraint for the propagation of textures. Moreover, in the creation of paintings, the artists normally start with sketch, and color the picture in the later step.

Generation of edge image

Firstly, edges are firstly extracted using already trained HED model. Then we adopt standard non-maximum suppression and edge thinning for the post-processing.

Experimental Results

Datasets: a) 137K Amazon Handbag images: contain simple and clear content and used to verify whether edges can formalize the structure of the completed objects. b) 100K-ImageNet dataset chosen at random in ImageNet: contain large variance in classes and background and used to test the overall performance of the proposed method.

Baselines: a) local information-based approaches: the total variation approach (TV) [3] and the exemplar-based approach (EB) [2]. b) learning-based approaches: the CE and CE implemented with WGAN loss (CE-W).

Results: In general, classical methods (TV, EB) can only produce blurred or cracked results in the tasks of completing large missing region. Results from context based approaches are more semantically correct than classical methods.

a) Clear environment: our edge completion network is able to draw the boundary of the object (Fig. 3 (d)). We can also notice that the final completed images (Fig. 3. (i)) from our method can fit well with the edge maps, verified that the edge maps have strong effects on the texture prediction.

b) Complex environment: our proposed method can successfully avoid texture penetration of neighboring object (e.g. row 1-3 in Fig 4). We attribute it to the edge map, which recovered the boundary between objects in the edge completion step.

Table 1. Quantitative comparison on 100K-ImageNet dataset.

<table>
<thead>
<tr>
<th>Method</th>
<th>Mean L1 loss</th>
<th>Mean L2 loss</th>
<th>PSNR</th>
<th>SSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>26.41%</td>
<td>14.91%</td>
<td>15.13 dB</td>
<td>0.495</td>
</tr>
<tr>
<td>CE-W</td>
<td>24.19%</td>
<td>13.15%</td>
<td>15.86 dB</td>
<td>0.515</td>
</tr>
<tr>
<td>Our method</td>
<td>22.50%</td>
<td>12.19%</td>
<td>16.07 dB</td>
<td>0.549</td>
</tr>
</tbody>
</table>

Table 1 reports the quantitative results of completed region on 100K-ImageNet dataset, which reveals similar trend with the qualitative results. The PSNR value of our methods is about 0.39 dB higher than CE-W and about 0.94 dB higher than CE.

Conclusion

In this paper, we proposed an edge-aware image inpainting method to handle deformed shapes in the previous learning based inpainting approaches. Moreover, according to the characteristics of binary edges, we developed an edge completion network. Compared to CE, our method can obtain images with better structures and correctly located textures. Experimental results demonstrated its superior performance on challenging image inpainting examples.