Transformation Guided Image Completion Supplementary material

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Abstract

In this supplementary document, we show more completion results on a variety of scenes and comparisons with unguided state-of-the-art image completion algorithms.

1. State-of-the-art Image Completion Algorithms

We compare results of the following state-of-the-art image completion algorithms:

- Criminisi *et al*. [3], whose technique is a greedy image completion algorithm with carefully considered filling order. It uses only translational patches.
- *Priority-BP* [6], which pose the problem as a labeling problem in a MRF framework and optimize the label assignment with priority-based belief propagation. It uses only translational patches. We use the implementation by Darren Lafreniere [1] with default parameters.
- *Photoshop Content-Aware Fill* [1], which implements Wexler *et al*.'s [8] space-time video completion algorithm along with PatchMatch [2]. We use the content-aware fill tool in Adobe Photoshop CS5 to generate the completion results. It uses only translational patches.
- *Transforming image completion* [7], which searches over scale and rotation for image completion. We use the implementation released by the authors[2]. We use default parameters and enabled all transformation. Unfortunately, the implementation does not support large images (e.g., larger than 300×400)[3]. For images larger than 300×400, we downsampled large images to half of the original size and processed the downsampled versions instead.
- *Image melding* [4], which augments the patch search space with additional geometric and photometric transformations, integrates image gradients and replaces the usual average color with the solution of a screened Poisson equation. Unfortunately, there is no publicly available implementation as of submission time. Instead, we use two of their examples for comparison (Figures 1 and 2).

[1] http://lafarren.com/image-completer/

[2] http://www.vision.ee.ethz.ch/~mansfiea/transformic/

[3] We typically ran out of memory when processing large image using [7]

2. Image Completion Comparisons

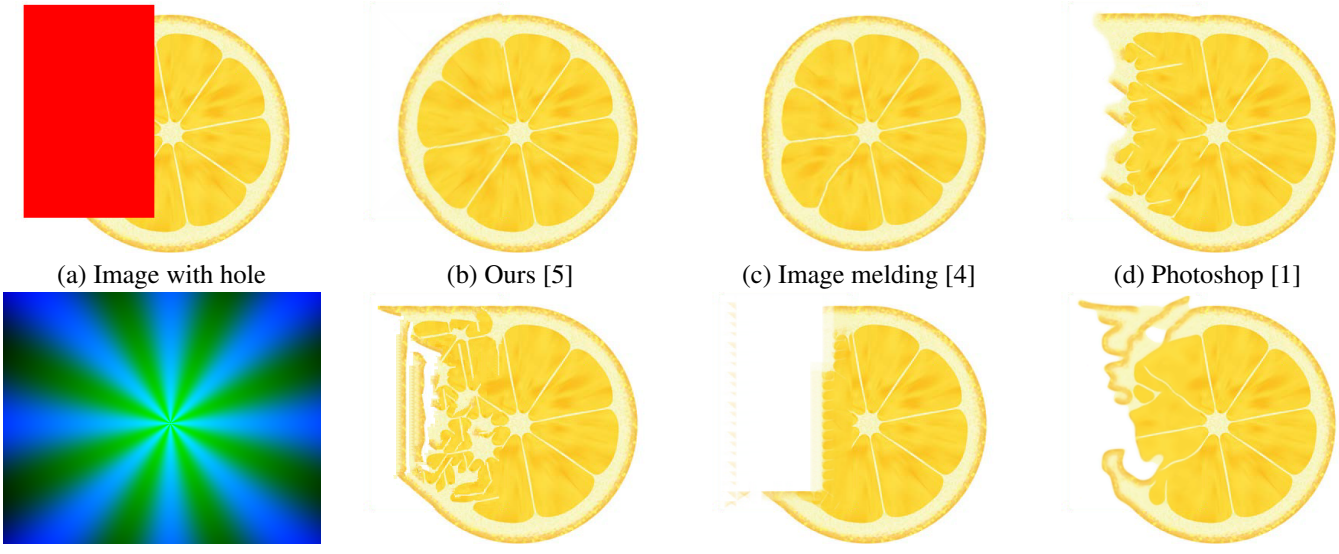
We first show comparisons to image melding using two examples in their paper. Then, we present more results on each of the image structural category. If the missing image content has no structures, i.e., no user inputs are required, our method reduces to an unguided image completion algorithm similar to Photoshop [1]. Our results for unguided image completion are shown in Figures 3(c), 5(c), 8(c), 10(c), 14(c), and 16(c).

2.1. Comparison to Image Melding [4]

We present comparisons with image melding [4] as well as with four other algorithms in Figures 1 and 2. Note that these two images are not easy cases as the missing content have certain structures. Failing to recover the meaningful structure will produces undesired artifacts, e.g., wiggly lines, broken structures, or blurriness.

2.2. Ramp Gradient

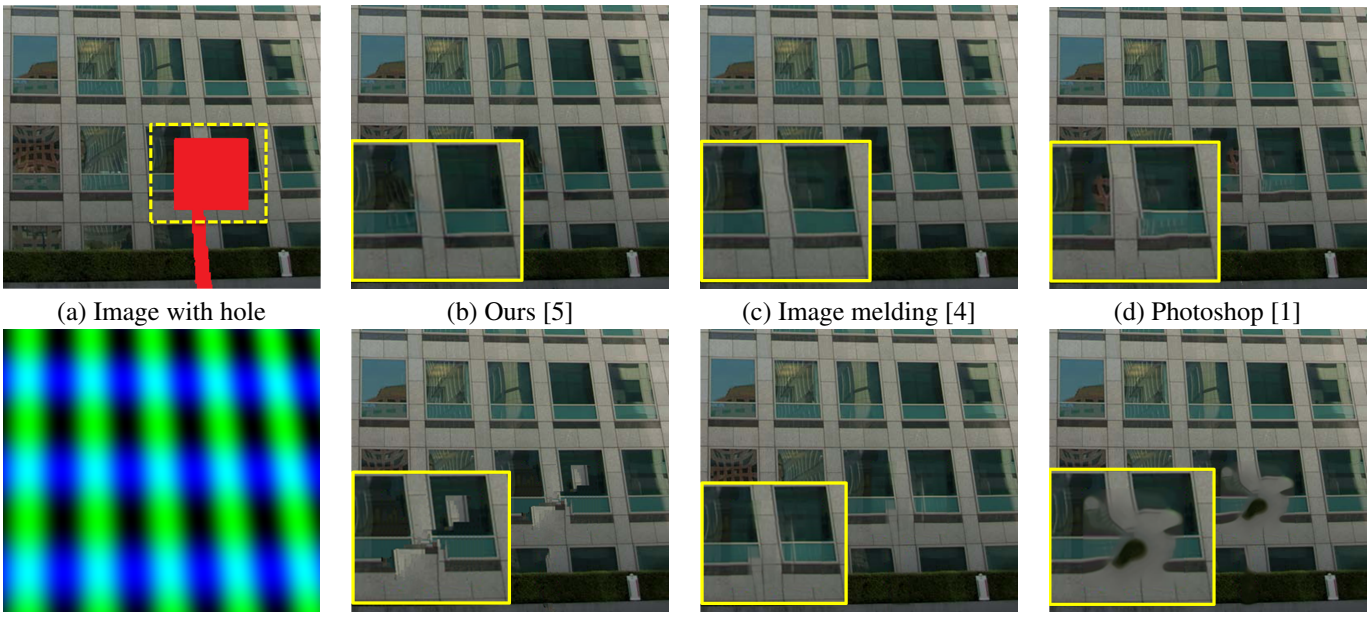
In Figures 3 and 4, we show two completion results using the ramp gradient tool. The ramp gradient is useful for images with linear or approximately linear structure in the background. For example, in the first row of Figure 3, the guidance map using ramp gradient encourages to search



(a) Image with hole (b) Ours [5] (c) Image melding [4] (d) Photoshop [1]

(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 1. Image completion comparison (a) input image with a hole (marked as red), where visible parts contain rotational symmetry; (b) ours (with guidance map (e)) [5]; (c) Image Melding [4]; (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7].

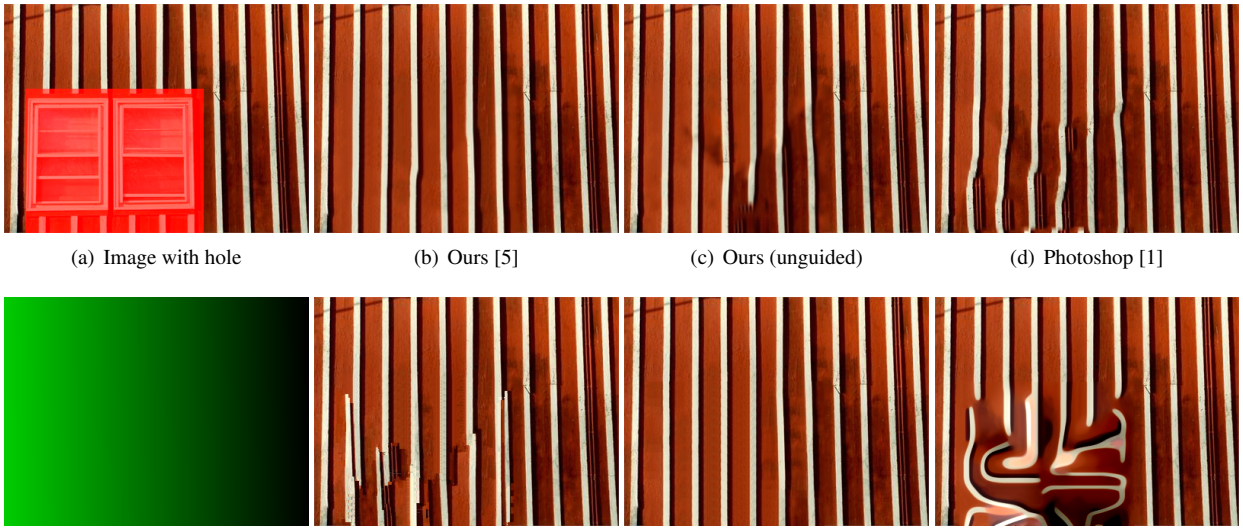


(a) Image with hole (b) Ours [5] (c) Image melding [4] (d) Photoshop [1]

(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 2. Image completion comparison (a) input image with a hole (marked as red), where visible parts contain rotational symmetry; (b) ours (with guidance map (e)) [5]; (c) Image Melding [4]; (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7].

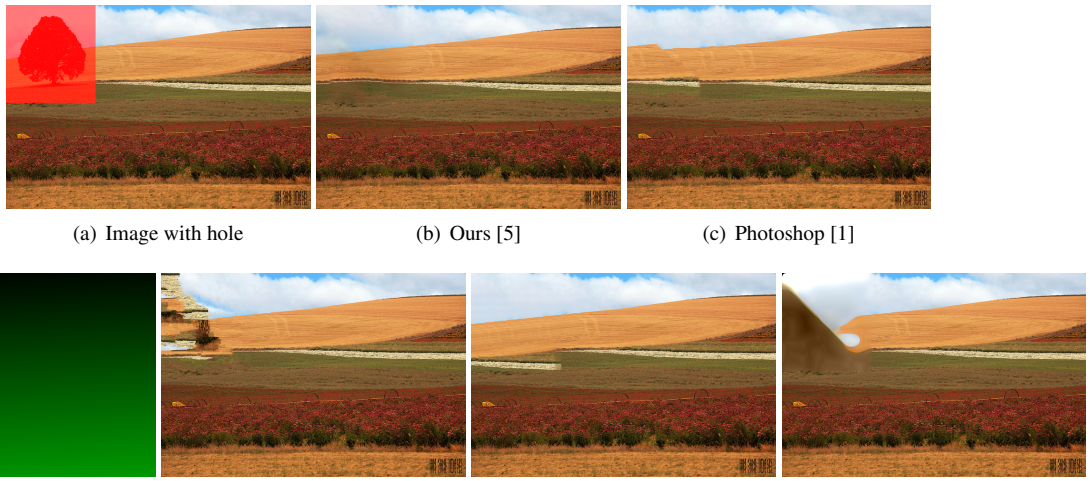
patches along vertical directions, thereby successfully recovering the underlying linear structure. The ramp gradient can also be applied to scenes with approximately linear structures (see Figure 4) since our constraints are soft. Note that even for these simple cases, unconstrained or unguided approaches [1, 3, 7, 6] are not able to produce satisfactory results.



(a) Image with hole (b) Ours [5] (c) Ours (unguided) (d) Photoshop [1]

(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 3. Image completion comparison on image with linear structures (a) input image with a hole (marked as red); (b) ours (with guidance map (e)) [5]; (c) ours without using guidance; (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7].



(a) Image with hole (b) Ours [5] (c) Photoshop [1]

(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

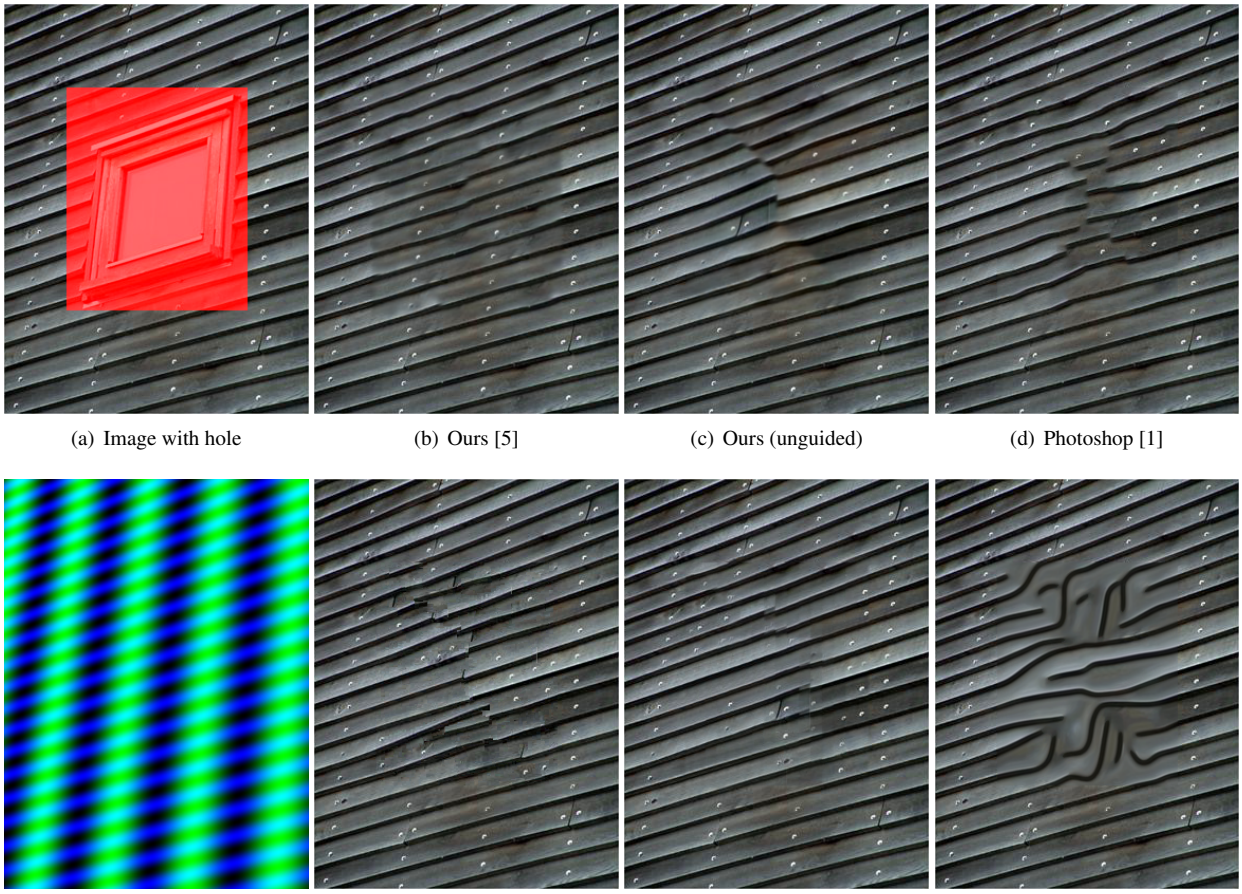
Figure 4. Image completion comparison on image with approximate linear structures (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7].

2.3. Translational symmetry

In Figures 5, 6, and 7, we show example results for images with translational symmetry. While this kind of symmetry is very common in man-made environments, it is challenging for automatic image completion algorithms because of the large search space for source patches. We show two 2D (Figures 5 and 6) and one 1D (Figure 7) translational symmetry examples. The required user inputs are four clicks for specifying the tile.

2.4. Reflective symmetry

In Figures 8 and 9, we show two completion results on images with reflective symmetry. With two clicks from the user, our system is able to produce high-quality completion results while other approaches fail.



(a) Image with hole (b) Ours [5] (c) Ours (unguided) (d) Photoshop [1]

(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 5. Image completion comparison (a) input image with a hole (marked as red); (b) ours (with guidance map (e)) [5]; (c) ours (without using guidance map); (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7]

Also note that in the first example (the occluded face), more than half the face is masked out. To account for that, in our implementation, we set the weight of the guidance map to zero for target pixels without known source patches over the reflective axis (i.e., the center of the face in the example).

2.5. Rotational symmetry

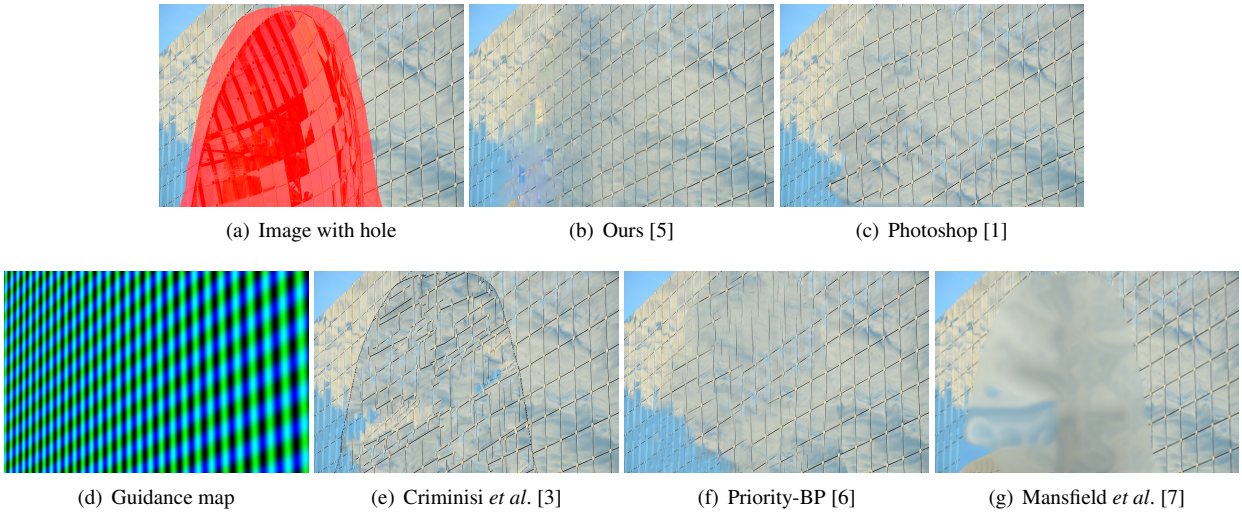
In Figures 10, 11, 12, and 13, we show four example images with rotational symmetry. Note that algorithms whose search space is translation only [1, 6, 3] have difficulties in handling these images. However, with transformation searching enabled (as in [7]), the optimization can easily converge to a bad local minimum, resulting in blurry reconstruction. With a single click from user, our system uses automatically generated guidance map to regularize the optimization process, thereby producing better results.

2.6. Composite guidance map

Many images are of scenes that consist of regions of different texture, surface, and structural properties. Combined with the label map approach, we can divide the complex scene into structurally consistent regions and apply user-specified structural constraints only within the selected region. In Figure 14, we show a window with reflective symmetry on a wooden wall. Thus, our guidance map consists of two regions, and apply reflective symmetry only to region corresponding to the window. Note that through user-specified surface orientation, various types of symmetry can adapt to the specified surface. In Figure 15, the scene is partitioned into three separate regions, each given a differently specified version of 1D translational symmetry.

2.7. Curved surface

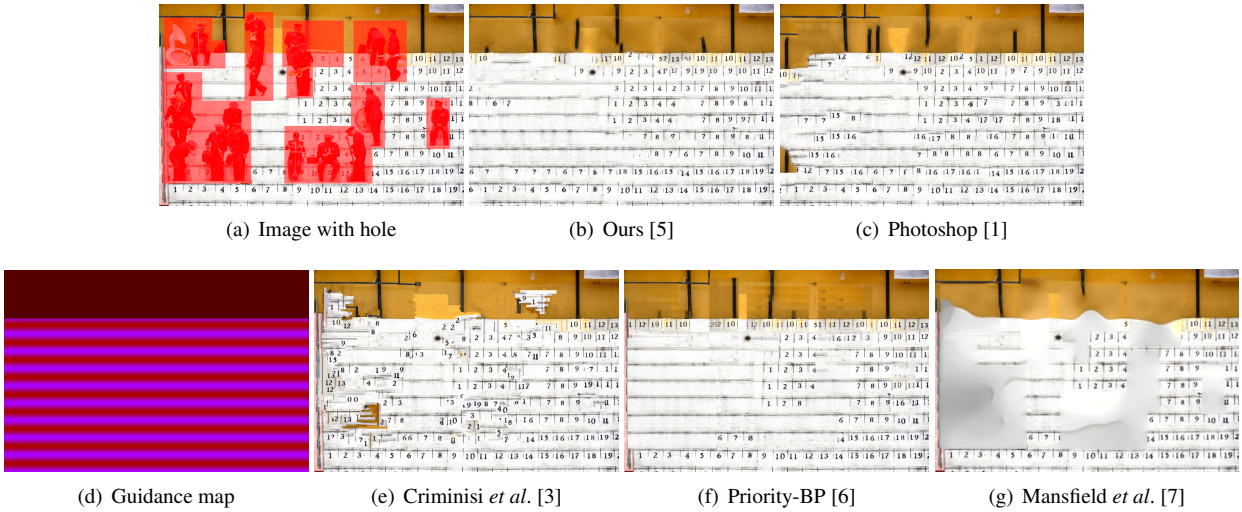
As stated in the paper, our system is less effective in handling images with structural regularity on a curved surface.



(a) Image with hole (b) Ours [5] (c) Photoshop [1]

(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 6. Image completion comparison (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]



(a) Image with hole (b) Ours [5] (c) Photoshop [1]

(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 7. Image completion comparison (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]

In Figures 16 and 17, we show two such examples. Our system is not able to produce the desired results. Notice, though, that other techniques also failed to generate satisfactory results.

References

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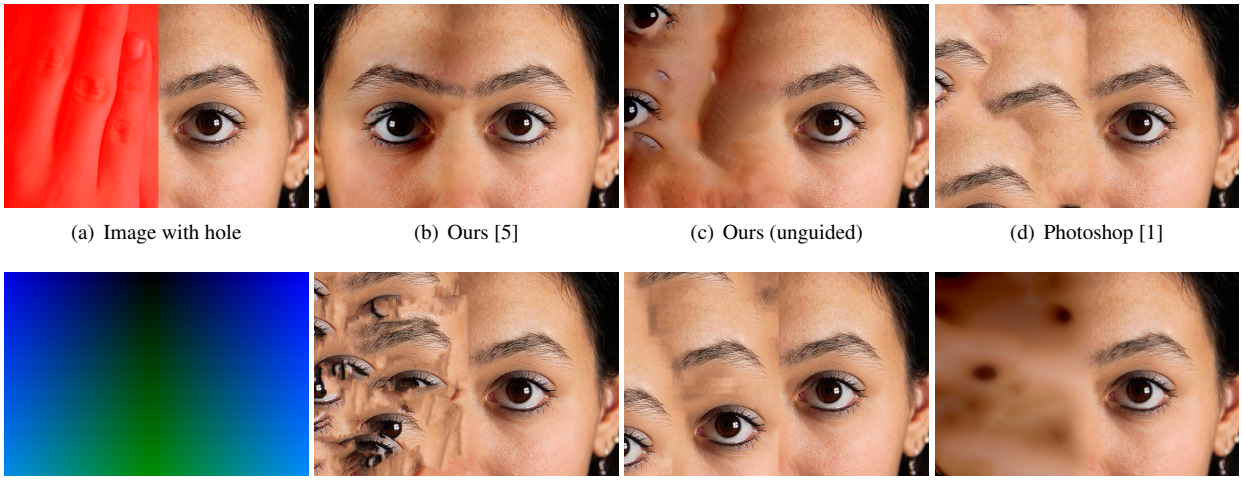

(a) Image with hole (b) Ours [5] (c) Ours (unguided) (d) Photoshop [1]

(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 8. Image completion results for images with reflective symmetry (a) input image with a hole (marked as red); (b) ours (with guidance map (e)) [5]; (c) ours (without using guidance map); (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7]

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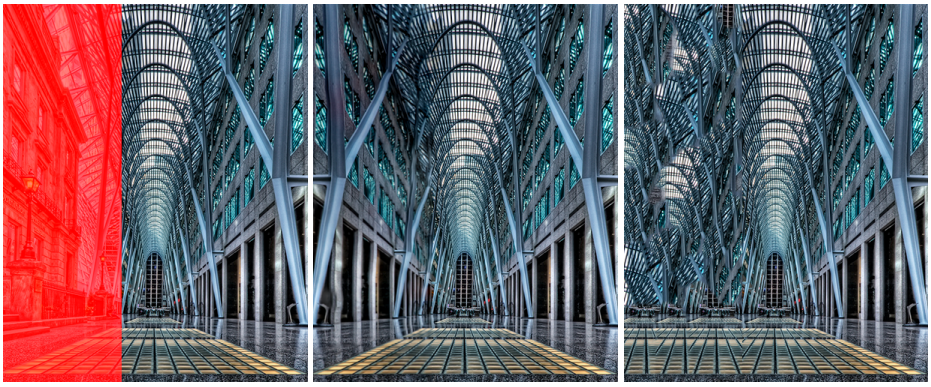
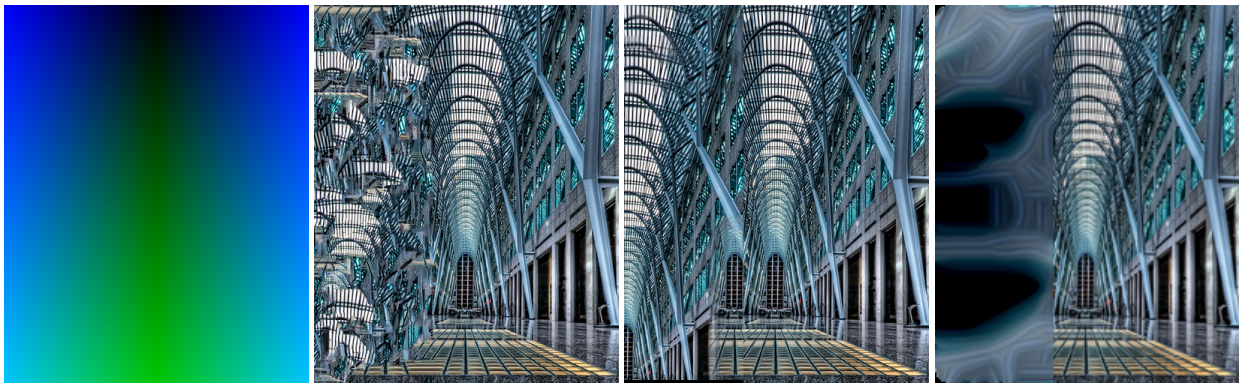
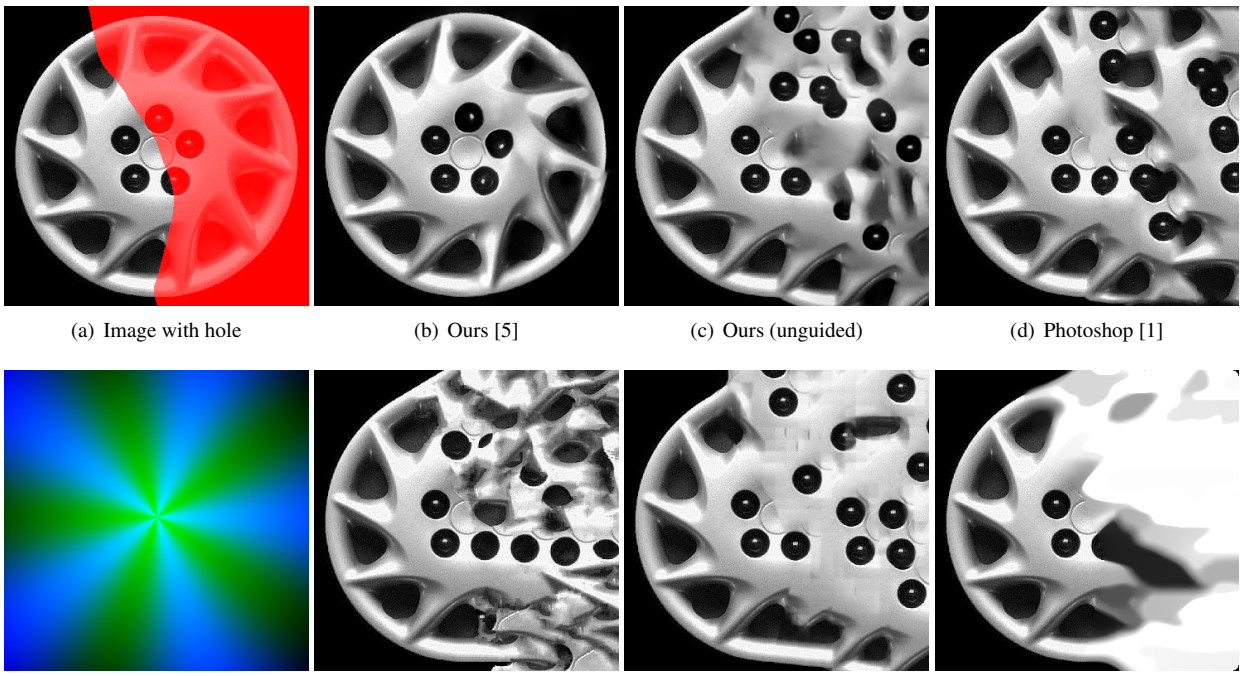


(a) Image with hole (b) Ours [5] (c) Photoshop [1]



(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 9. Image completion results for images with reflective symmetry (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]



(a) Image with hole (b) Ours [5] (c) Ours (unguided) (d) Photoshop [1]

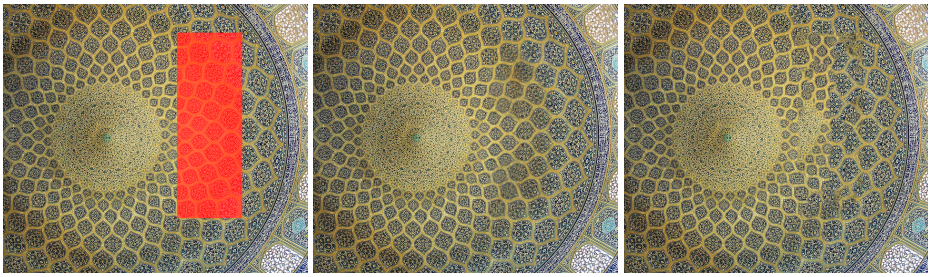
(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 10. Image completion results for images with rotational symmetry (a) input image with a hole (marked as red); (b) ours (with guidance map (e)) [5]; (c) ours (without using guidance map); (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7]

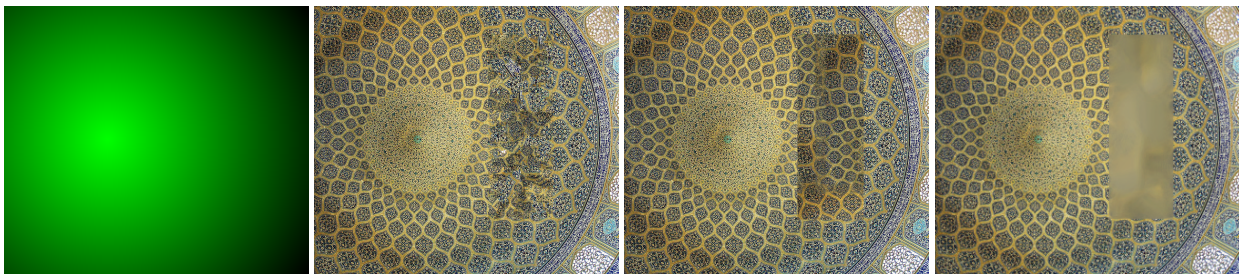
(a) Image with hole (b) Ours [5] (c) Photoshop [1]

(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 11. Image completion results for images with rotational symmetry (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]

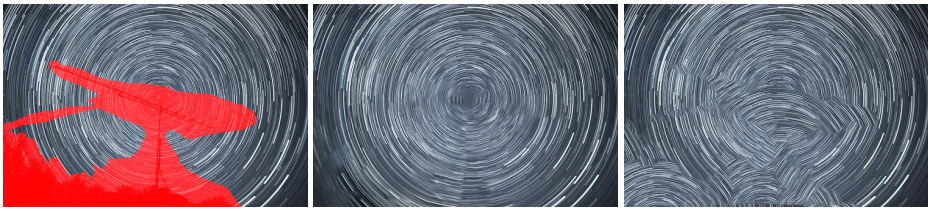


(a) Image with hole (b) Ours [5] (c) Photoshop [1]

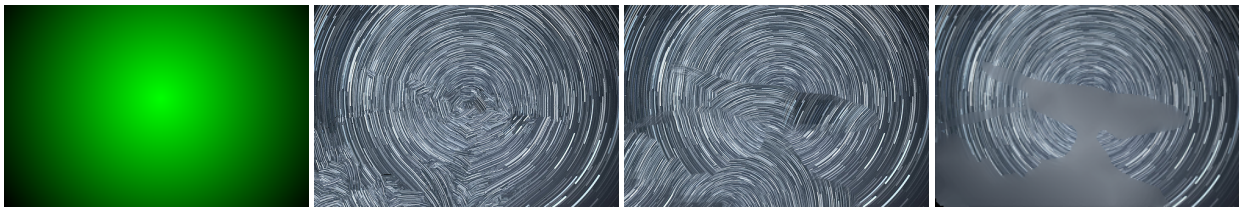


(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 12. Image completion results for images with reflective symmetry (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]



(a) Image with hole (b) Ours [5] (c) Photoshop [1]



(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 13. Image completion results for images with rotational symmetry (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]

(a) Image with hole (b) Ours [5] (c) Ours (unguided) (d) Photoshop [1]

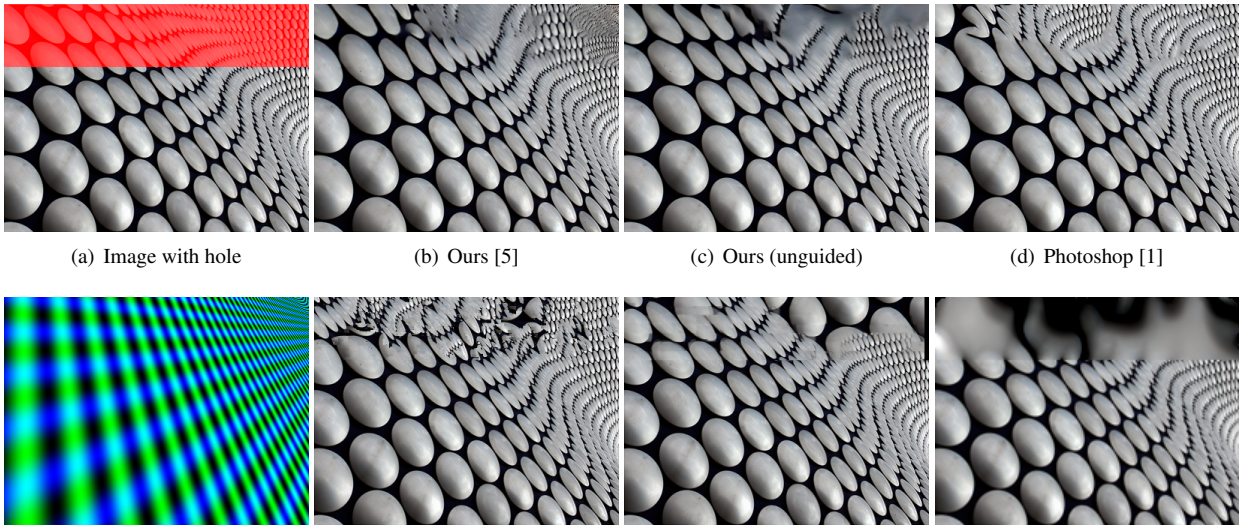
(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 14. Image completion results for images with regions of different structural properties (a) input image with a hole (marked as red); (b) ours (with guidance map (e)) [5]; (c) ours (without using guidance map); (d) Photoshop Content-Aware Fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7]

(a) Image with hole (b) Ours [5] (c) Photoshop [1]

(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

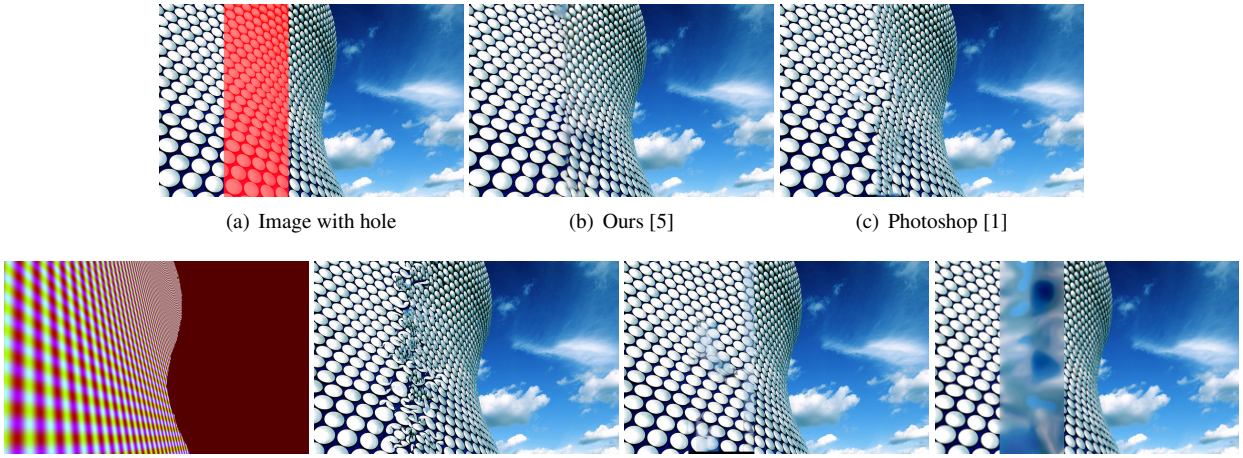
Figure 15. Image completion results for images with regions of different structural properties (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c)Photoshop Content-Aware Fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]



(a) Image with hole (b) Ours [5] (c) Ours (unguided) (d) Photoshop [1]

(e) Guidance map (f) Criminisi *et al*. [3] (g) Priority-BP [6] (h) Mansfield *et al*. [7]

Figure 16. Image completion results for images with curved surfaces (a) input image with a hole (marked as red); (b) ours (with guidance map (e)) [5]; (c) ours (without using guidance map); (d) photoshop content-aware fill [1]; (e) positional guidance map; (f) Criminisi *et al*. [3]; (g) Priority-BP [6]; (h) transforming image completion [7]



(a) Image with hole (b) Ours [5] (c) Photoshop [1]

(d) Guidance map (e) Criminisi *et al*. [3] (f) Priority-BP [6] (g) Mansfield *et al*. [7]

Figure 17. Image completion results for images with translation symmetry on a curved surface (a) input image with a hole (marked as red); (b) ours (with guidance map (d)) [5]; (c) photoshop content-aware fill [1]; (d) positional guidance map; (e) Criminisi *et al*. [3]; (f) Priority-BP [6]; (g) transforming image completion [7]