

# Shadow Detection and Sun Direction in Photo Collections: Supplemental Material

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## 1. Quantitative Sun Direction Results for TENTACLE

Figure 1 shows a histogram of sun direction errors for the TENTACLE dataset.

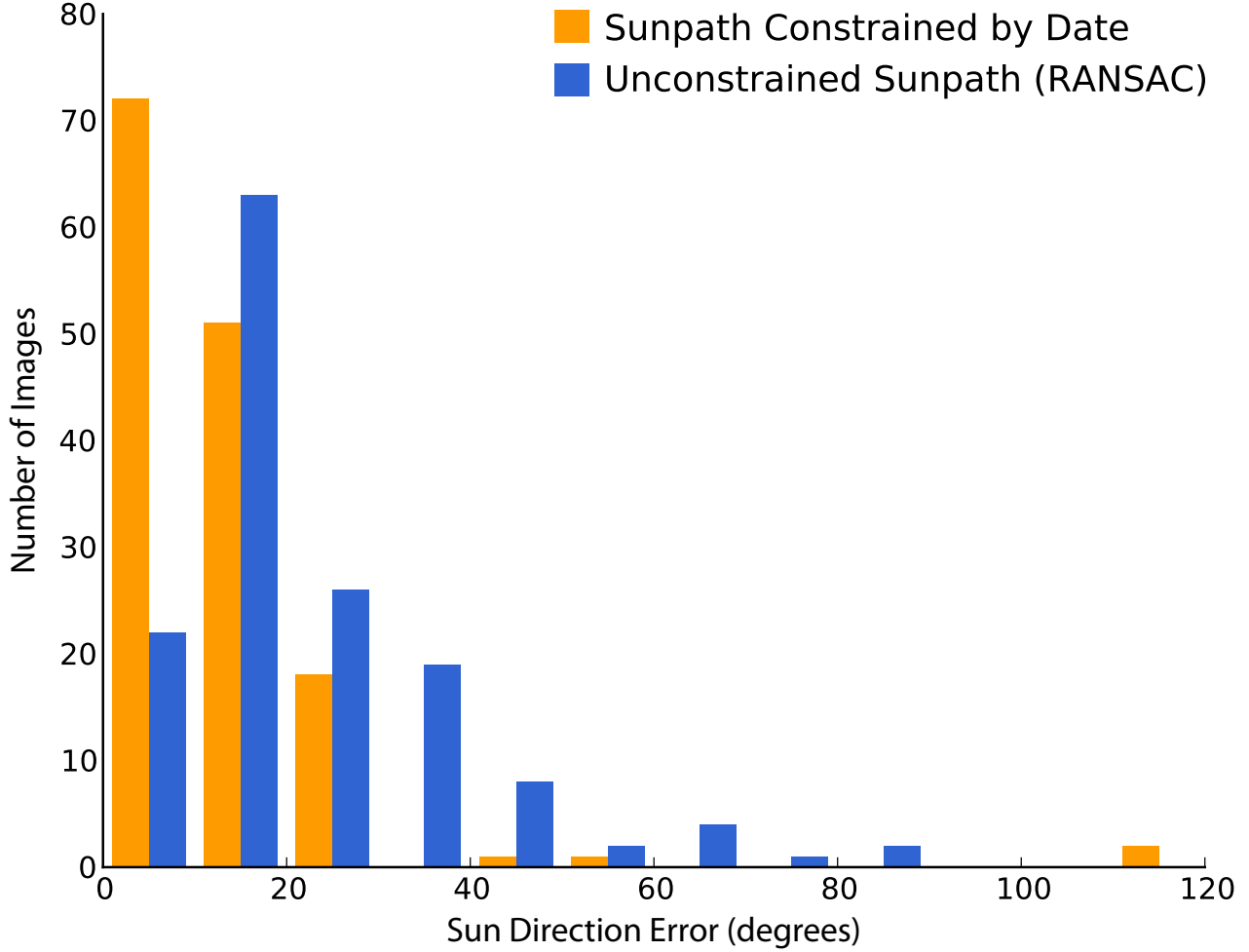


Figure 1. A histogram of absolute error for our sun direction estimation methods. The median error of the unconstrained RANSAC approach is  $17.5^\circ$ ; given the date and orientation of the scene, the constrained sun path approach achieves a median error of  $10.9^\circ$ .

## 2. Additional Comparisons to Sunkavalli *et al.* [1]

Figure 2 compares our method and FTLV to ground truth shadow labels generated using the 3D model of the TENTACLE dataset. Both methods work well in most areas but have difficulty in regions that are never sunlit.

Figure 3 shows an expanded comparison on TEMPLE, one of the webcam datasets used in the FTLV paper and made available online. Our method produces consistently cleaner and higher-detail shadows. Note that their full method involves a bilateral filtering post-processing step; we omitted this from our comparisons because both methods are per-pixel and could benefit equivalently from bilateral filtering and they did not provide the filtering parameters they used.



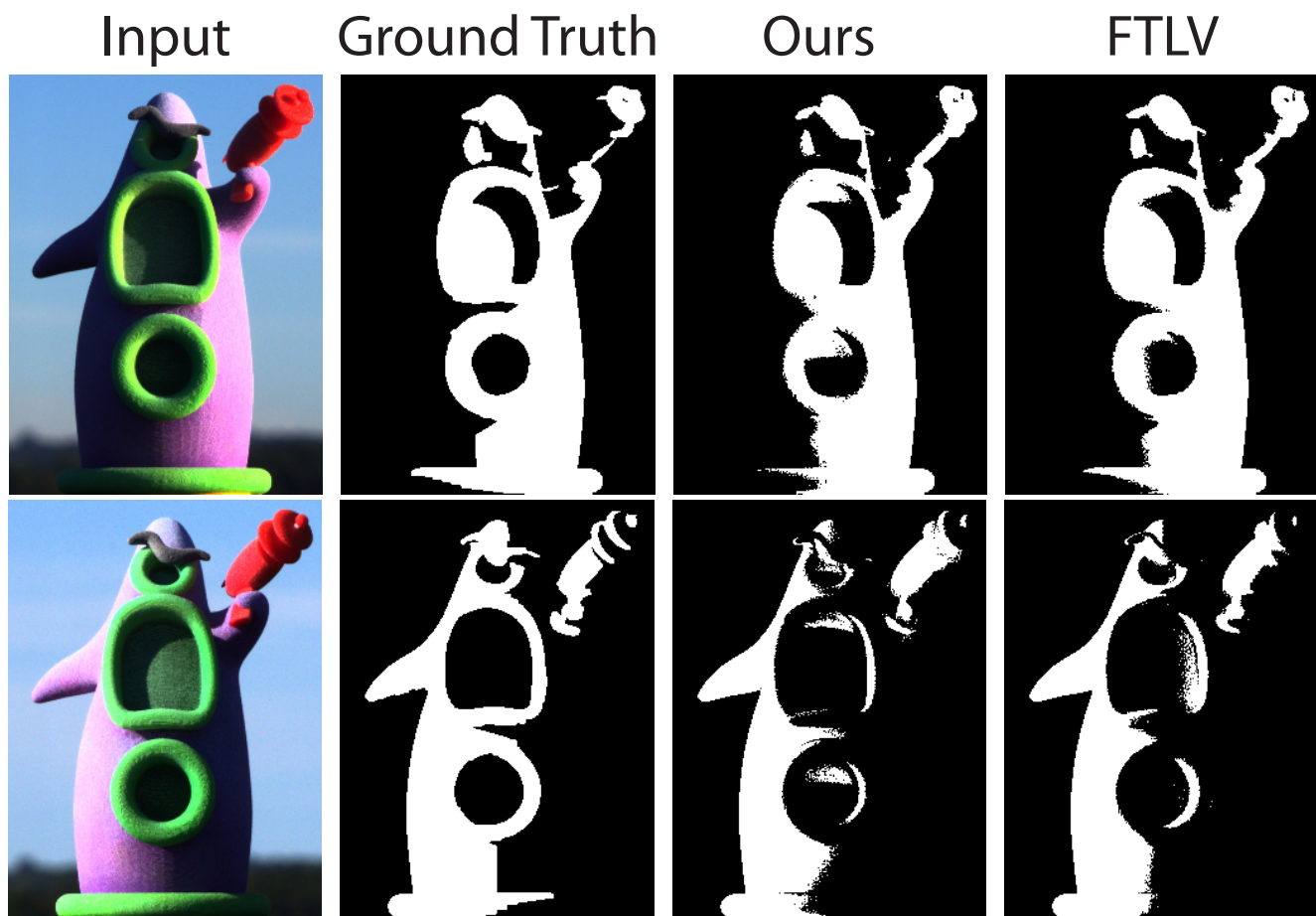


Figure 2. Example shadow results on TENTACLE. We show ground truth labels, our results, and FTLV.

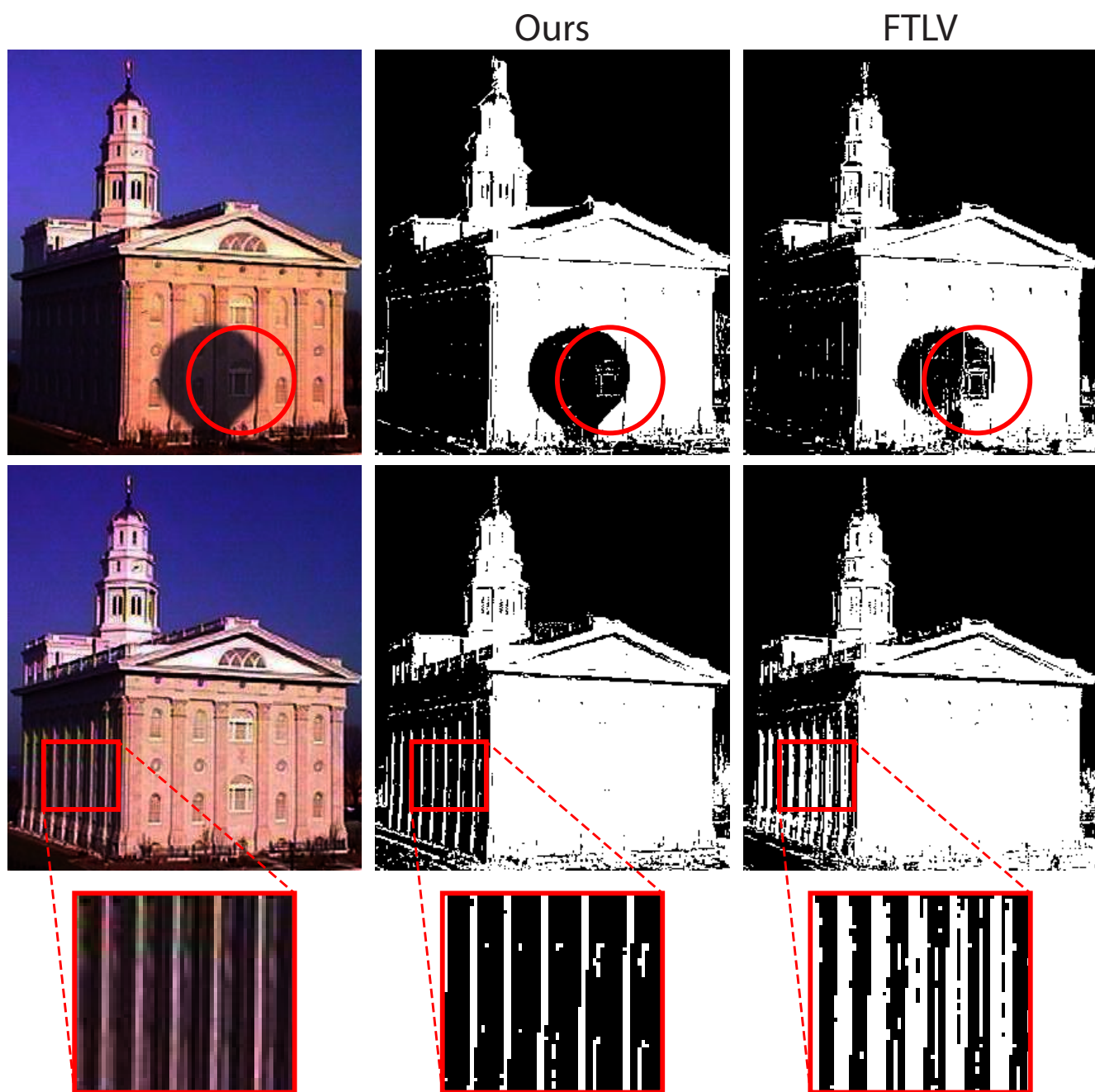
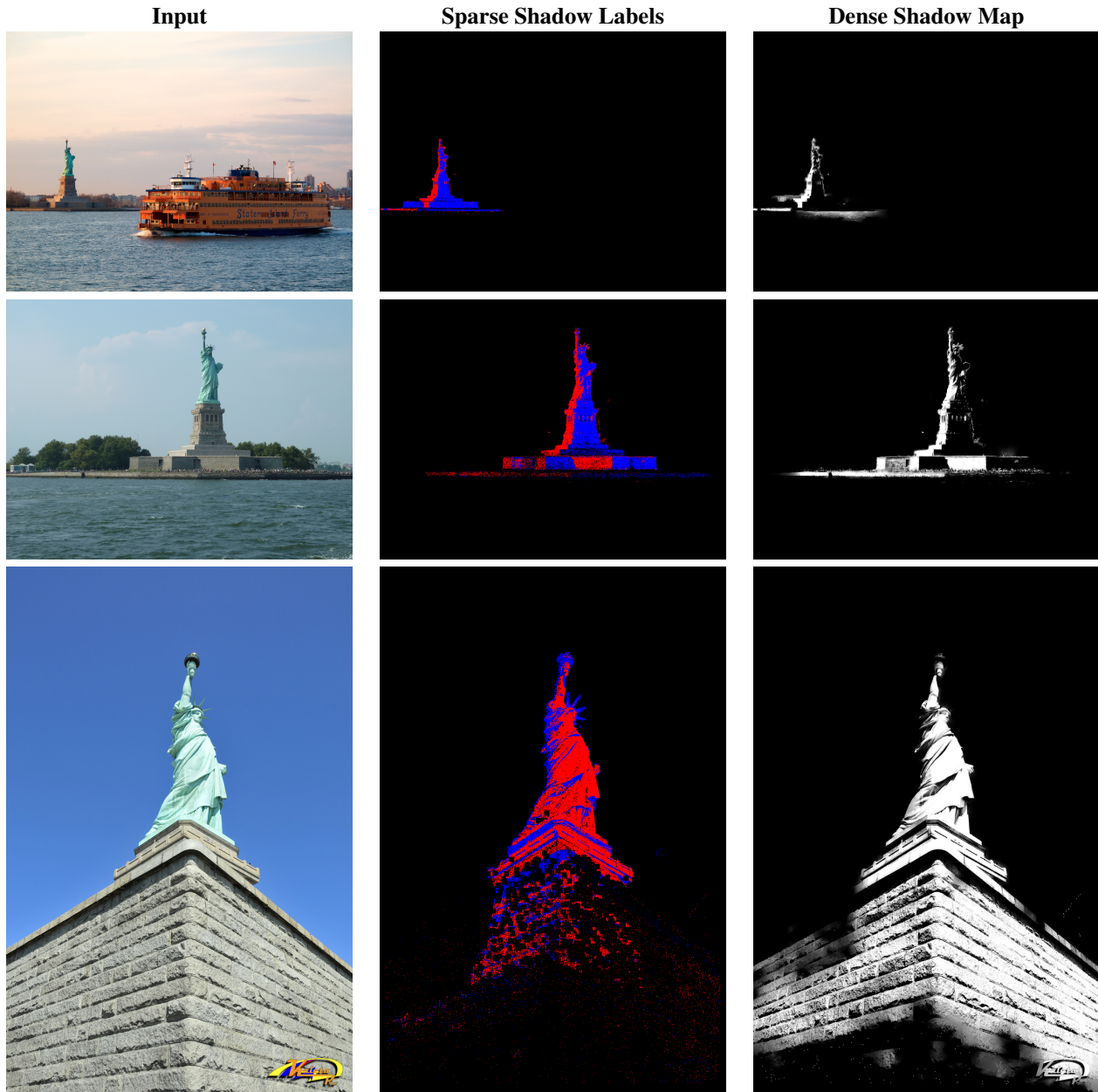
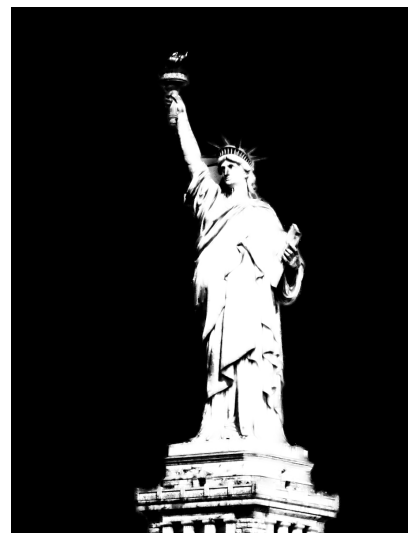
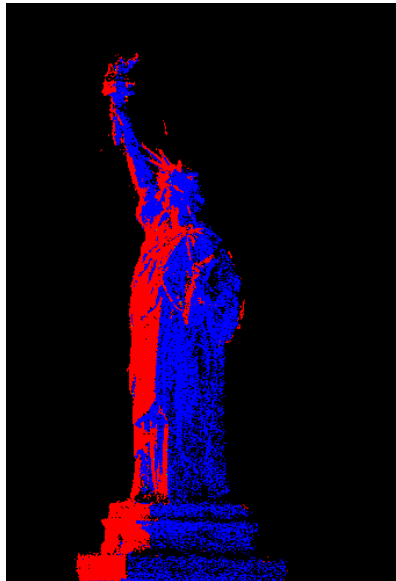
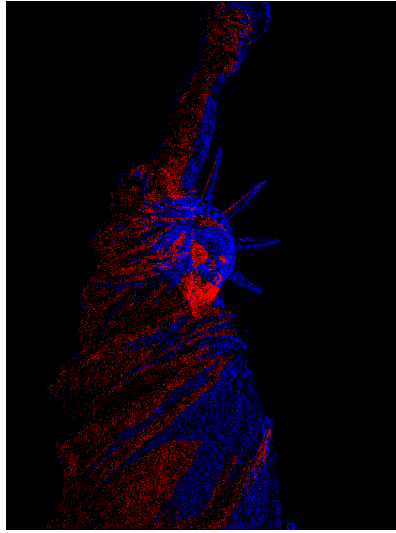


Figure 3. A comparison between FTLV and our method on TEMPLE, one of FTLV’s webcam datasets. Our method detects cleaner shadows in areas of high detail and variable albedo.

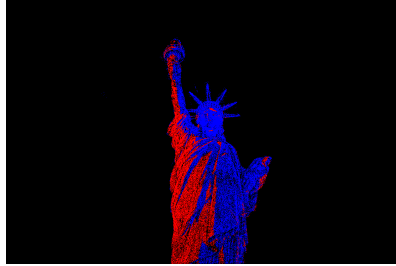
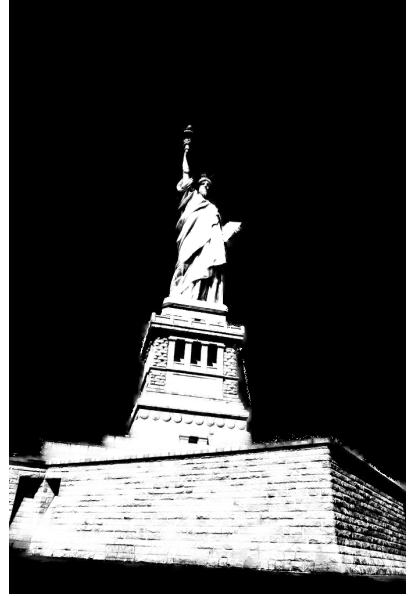
### 3. Additional Shadow Detection Results

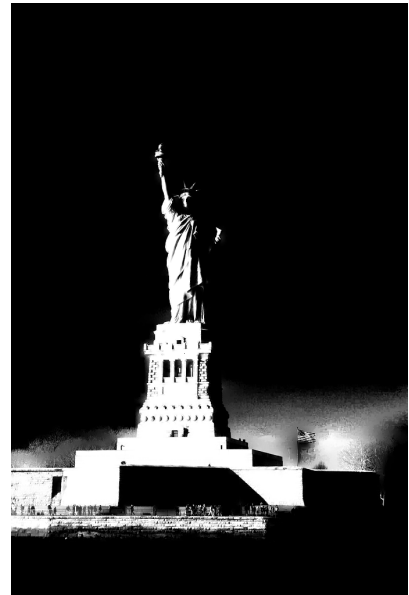
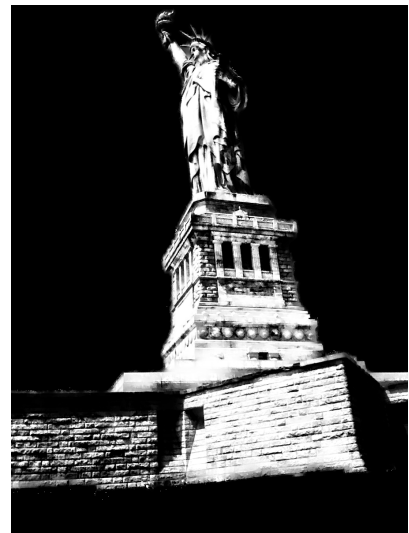
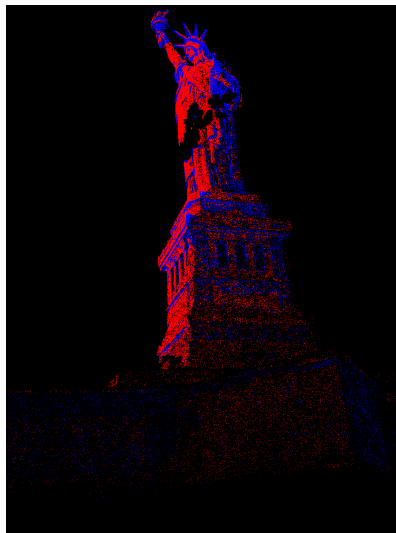
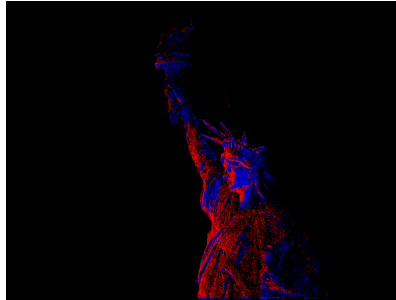
In this section we show a **randomly selected** subset of 30 sparse and dense results from each of the evaluation sets for STATUE and CASTLE. To deal with sky pixels in the dense result where a shadow labeling would be ill-defined, we use a standard image segmentation technique and assign a known “shadow” label to all pixels in image segments into which with few or no 3D points project. Although this results the sky in most images being consistently labeled in shadow in the dense result, occasionally the segmentation fails to separate the foreground from the sky, so some sky pixels are not held fixed in the matting process. We did not work to correct this because sky segmentation remains a challenge that is not the focus of this work; the segmentations are also easy to correct manually.

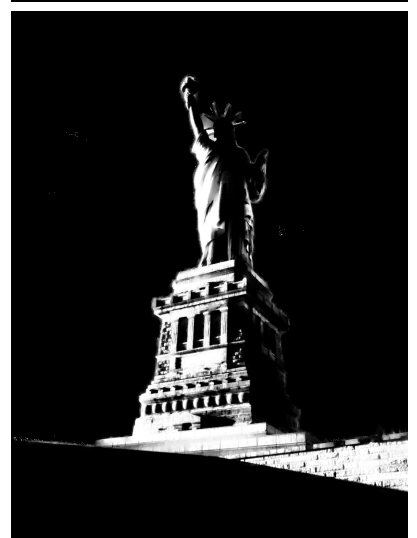
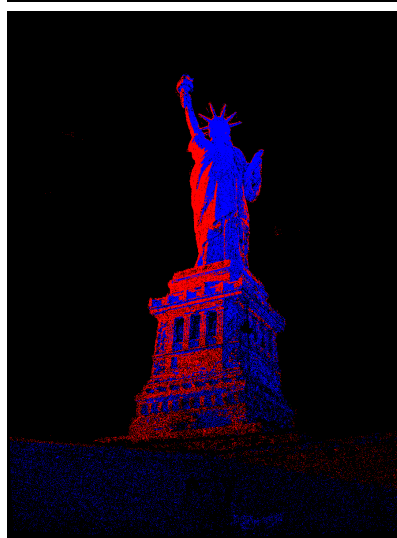
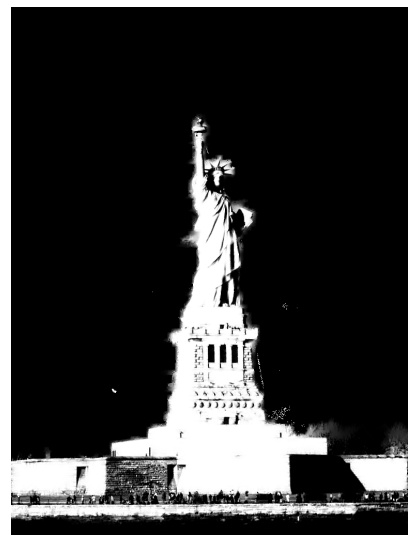




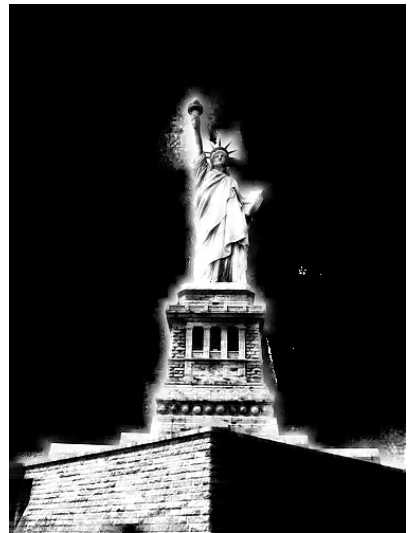
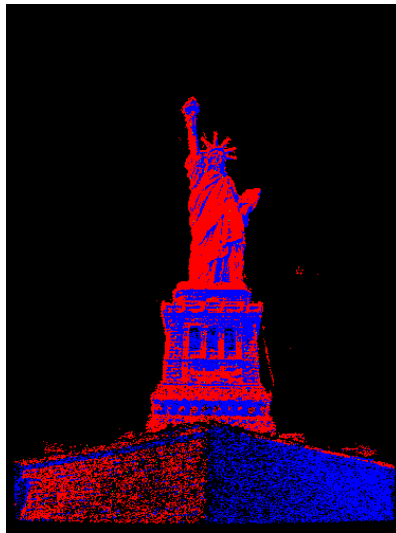




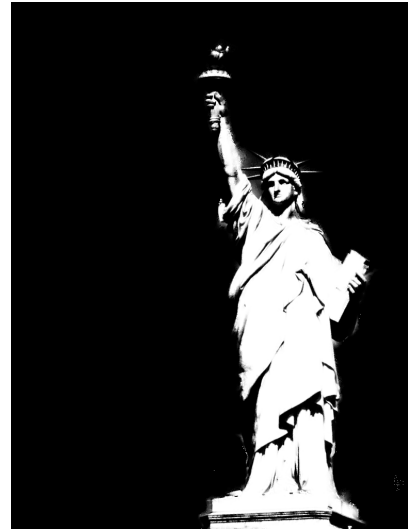
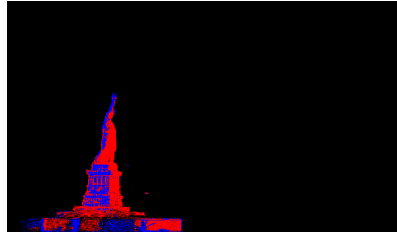
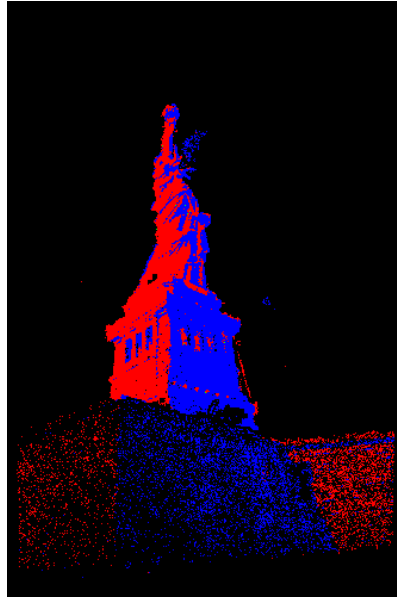


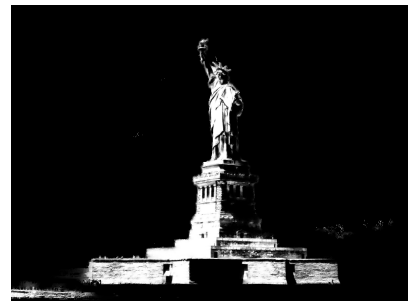
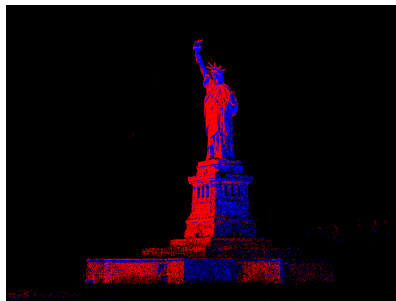
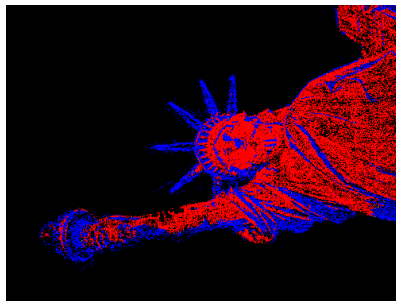
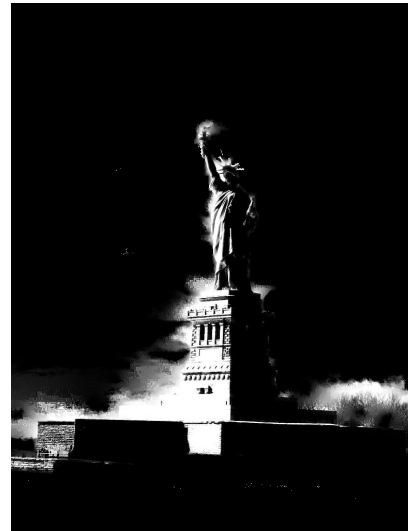
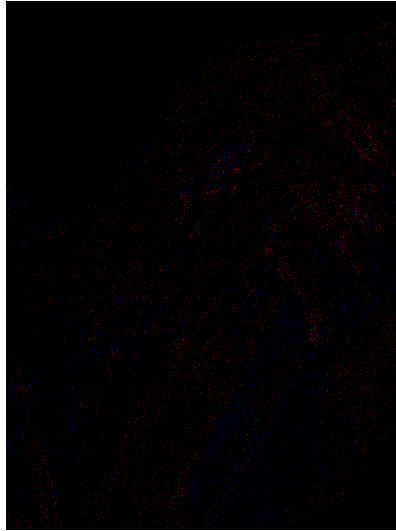




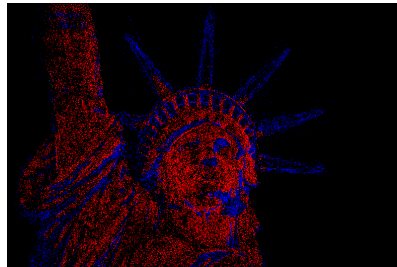
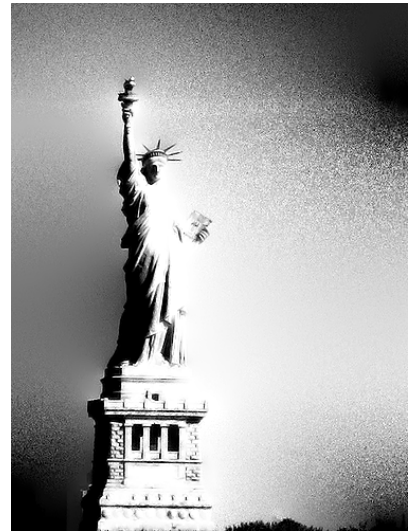


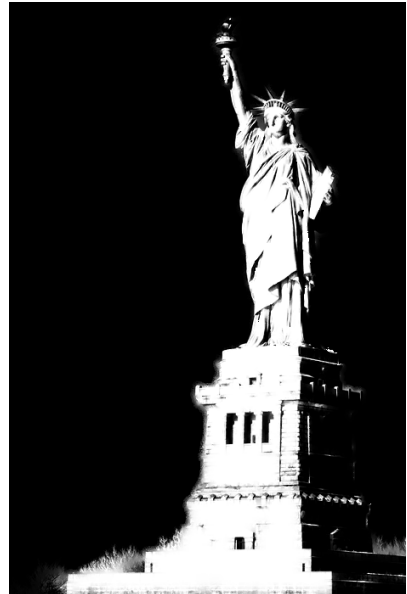
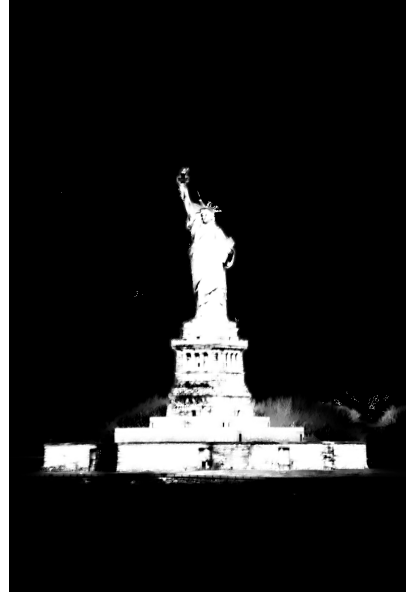










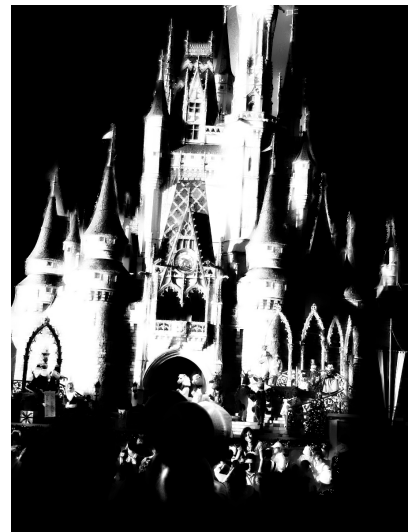
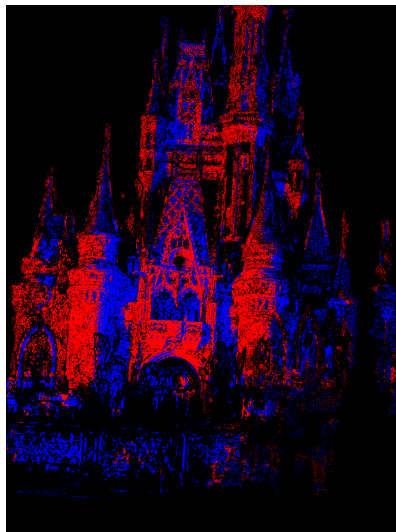
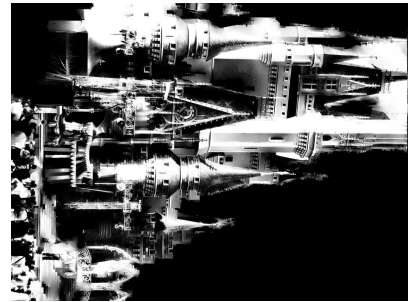
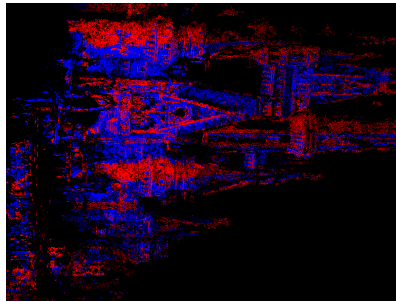
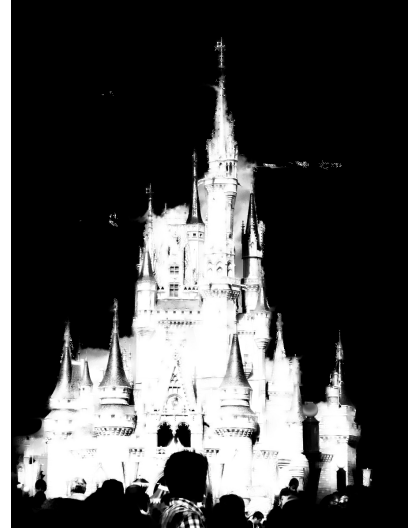
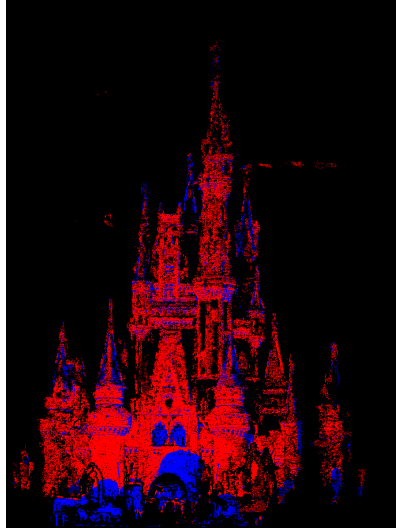


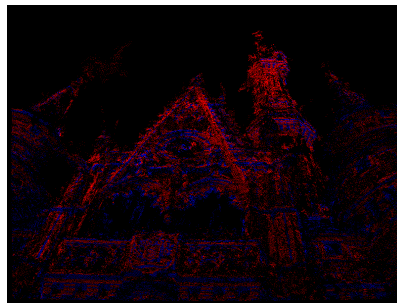
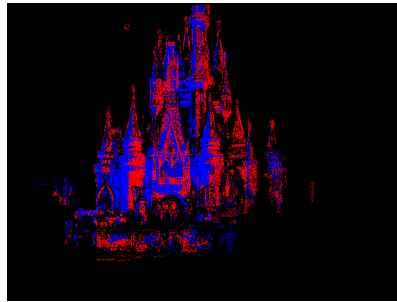
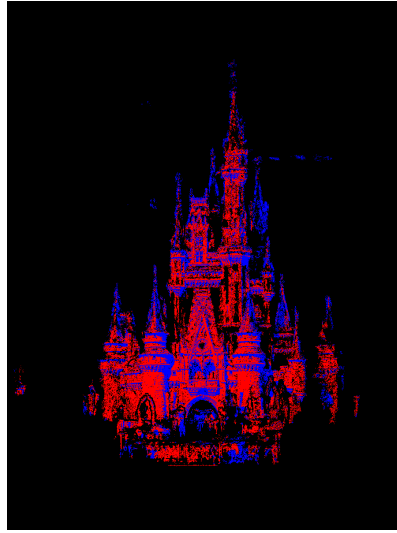
**Input**

**Sparse Shadow Labels**

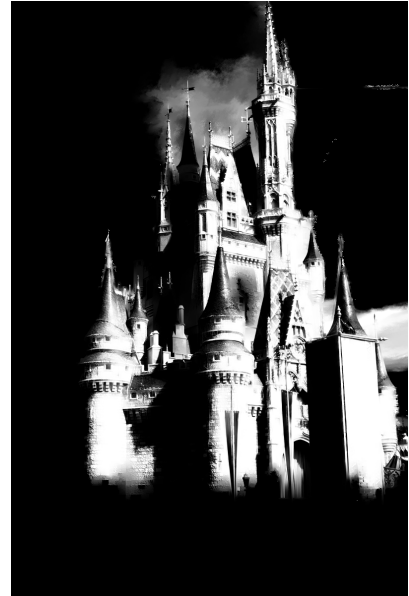
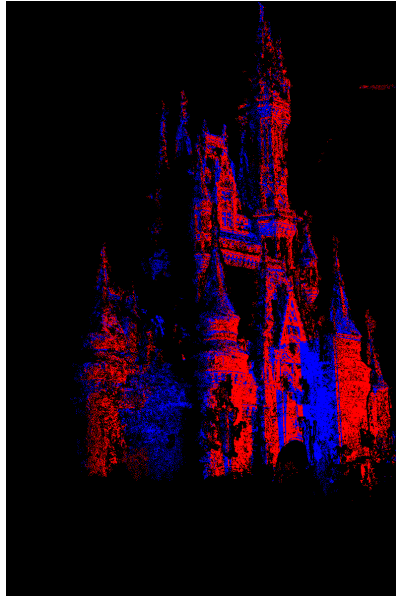
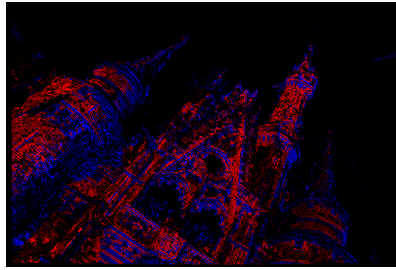
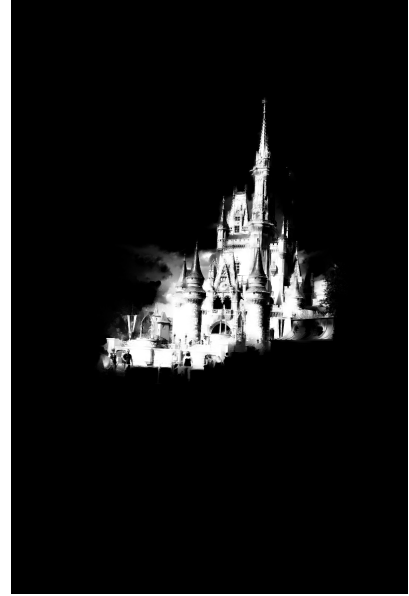
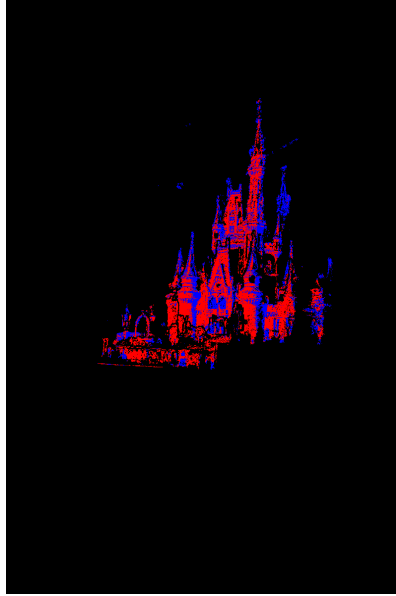
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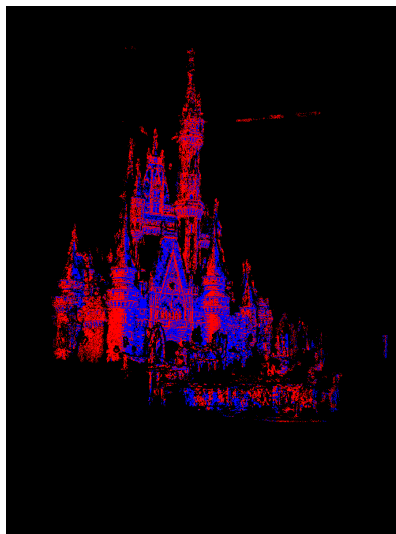
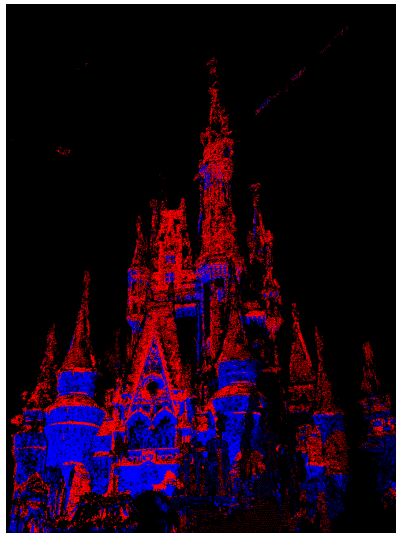
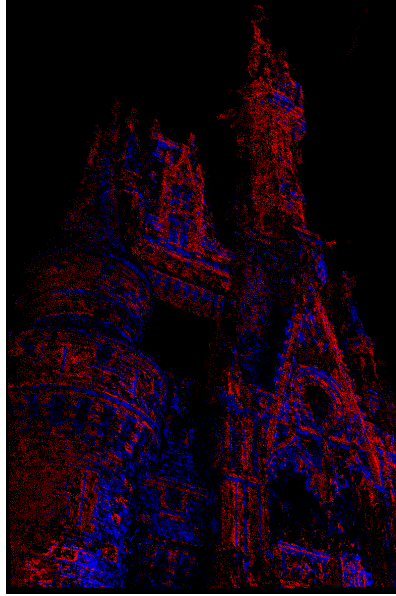




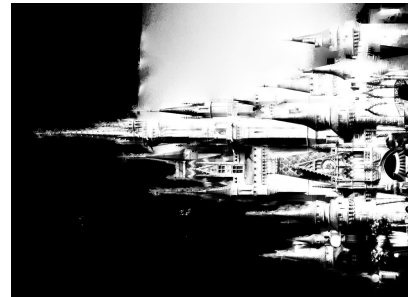
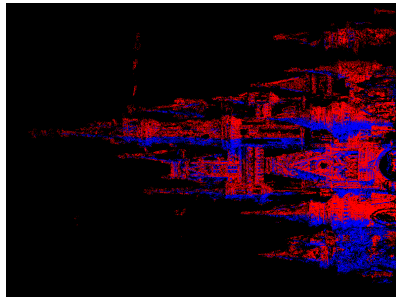
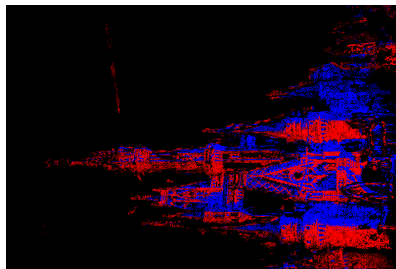
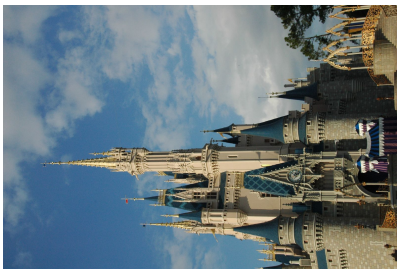
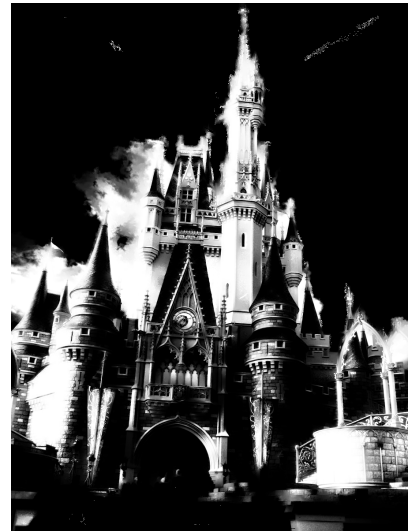
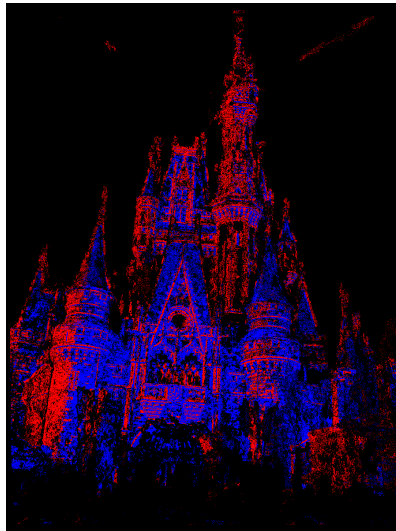
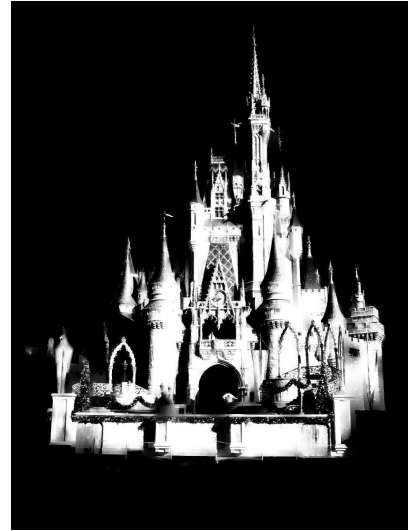
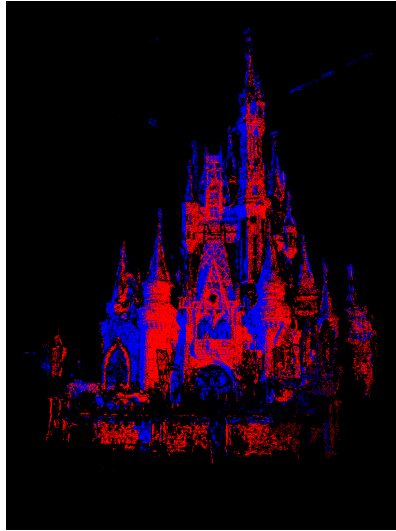


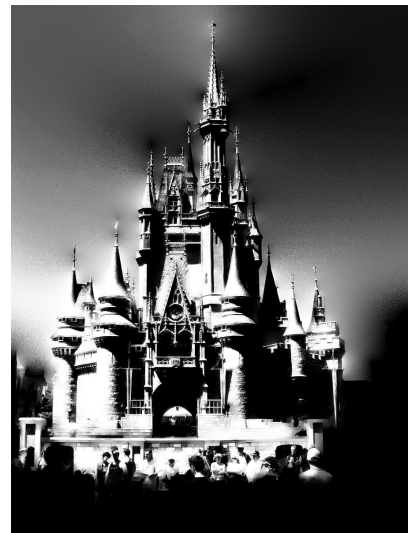
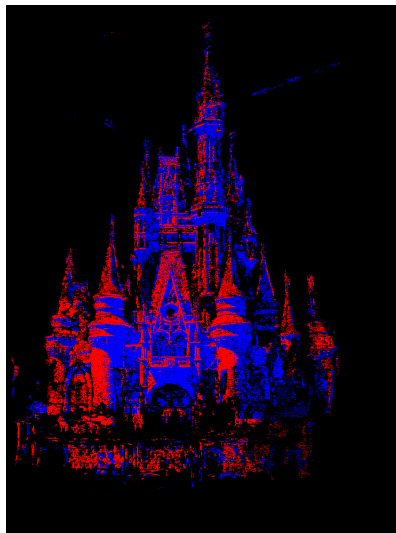
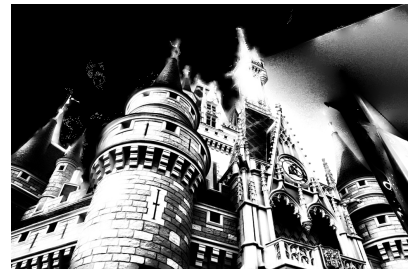
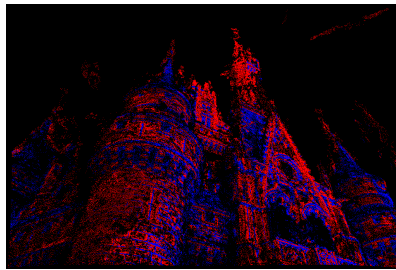
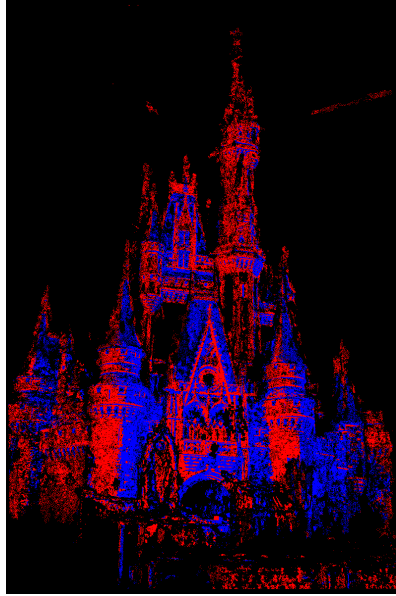




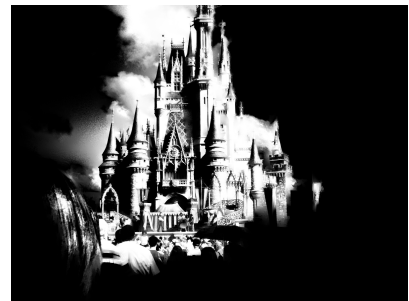
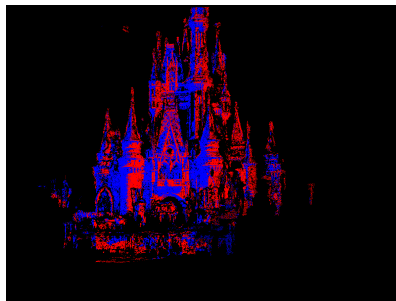
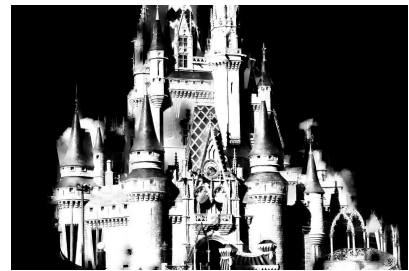
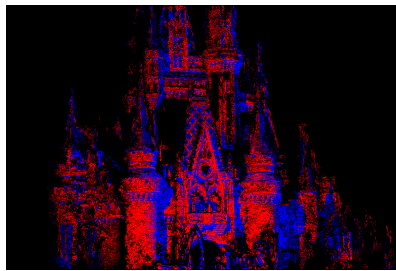
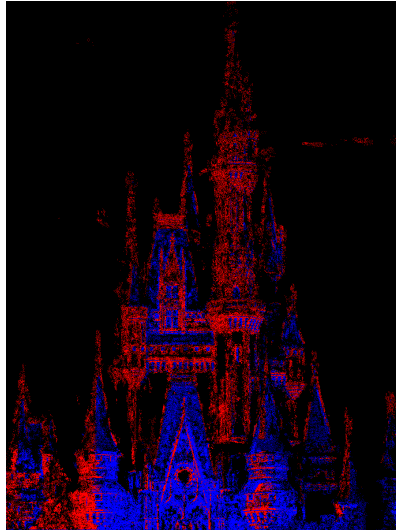


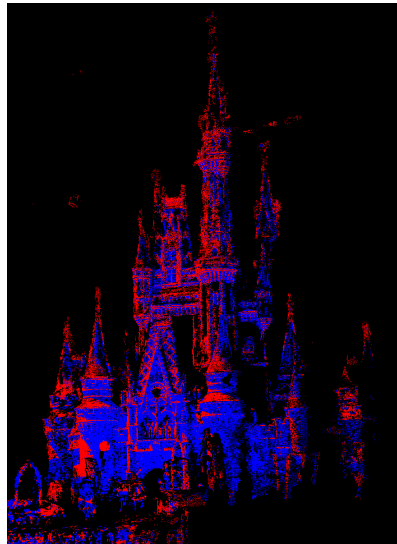
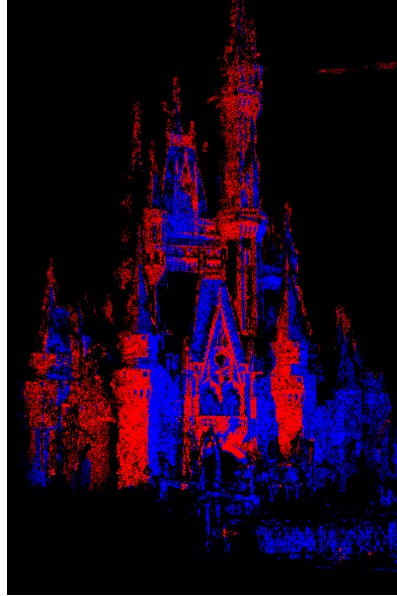




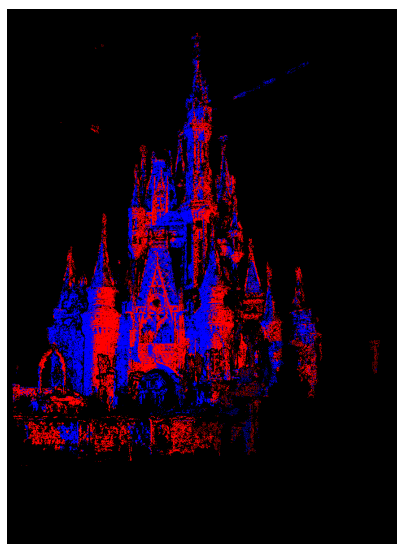
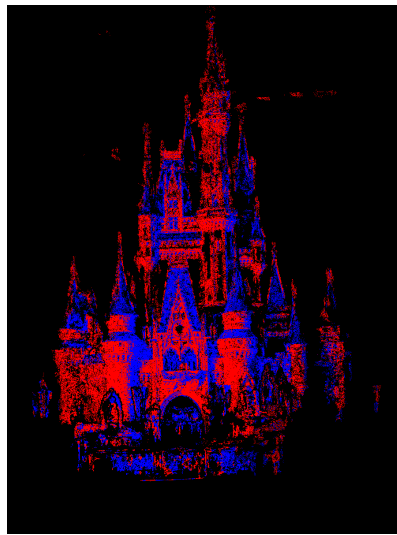
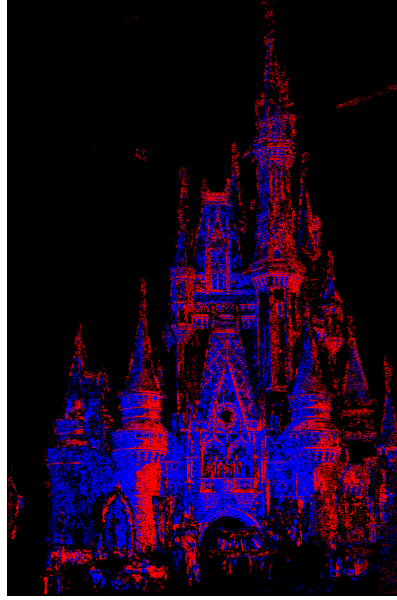


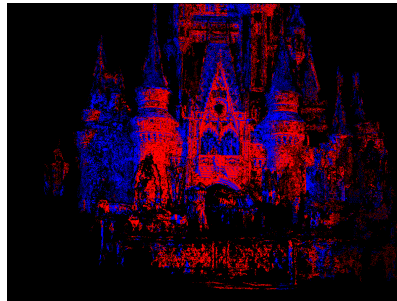
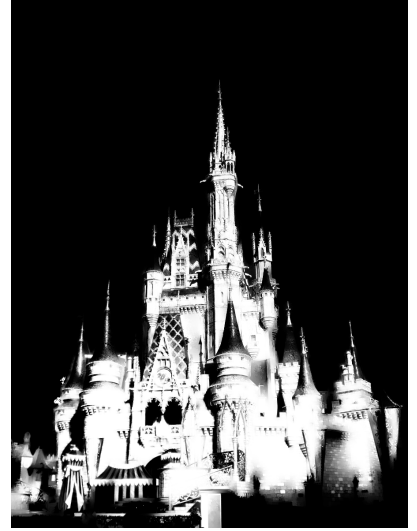
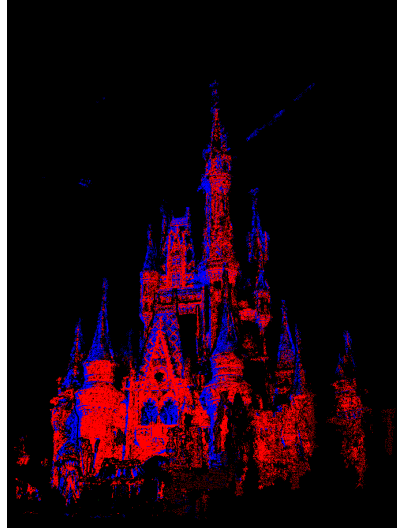
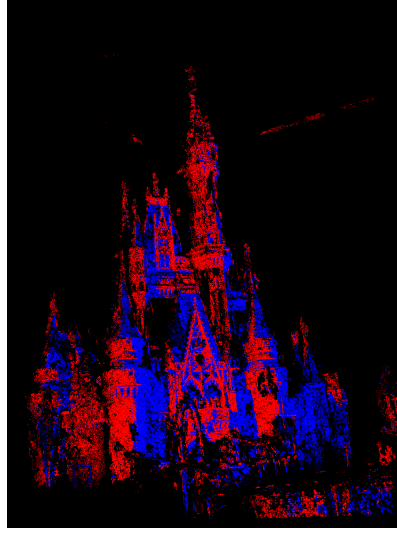












#### 4. Additional Qualitative Sun Direction results

This section shows 9 additional sun direction results for CASTLE and STATUE from the evaluation sets. The rendered scenes below each image show the sun directions estimated by our RANSAC-based method and our constrained sun-path approach. The STATUE set is easier for our method because the irregular folds in the statue's cloak provide many cast shadows; CASTLE is more challenging because of foreground clutter and occlusions, and because many of the typical shadows for this scene are cast or have boundaries on a crease.





RANSAC

Constrained



RANSAC

Constrained



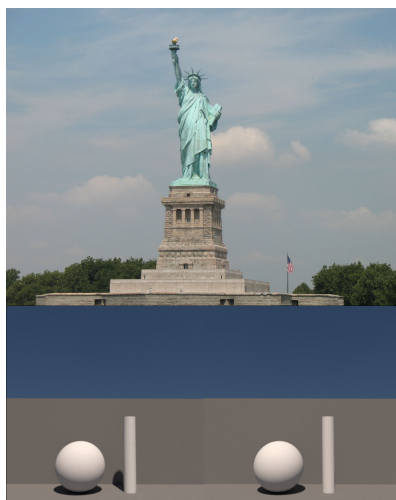
RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained



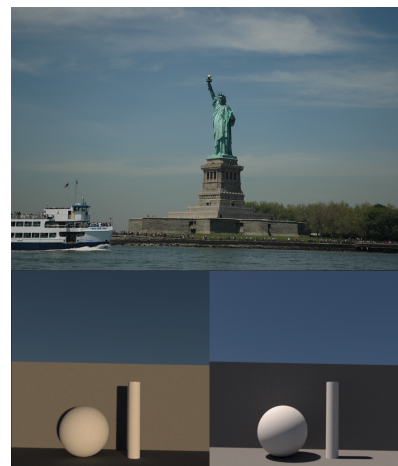
RANSAC

Constrained



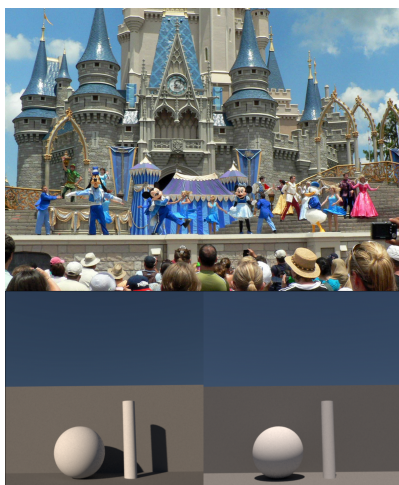
RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained



RANSAC

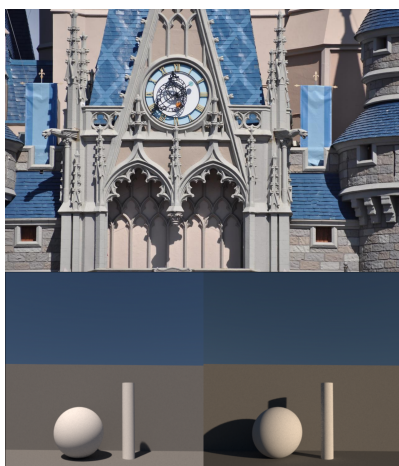
Constrained



RANSAC

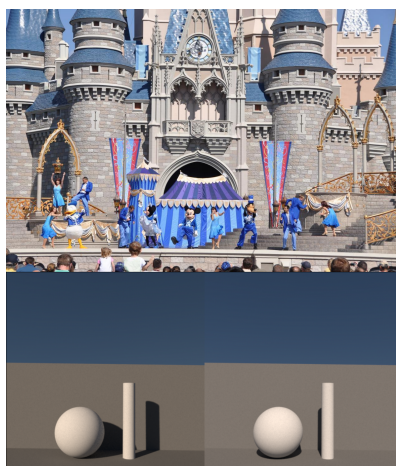
Constrained





RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained



RANSAC

Constrained

## References

- [1] K. Sunkavalli, W. Matusik, H. Pfister, and S. Rusinkiewicz. Factored time-lapse video. In *SIGGRAPH*, 2007.