Reflection Removal in Images

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Motivation

Images taken through a window or plane of glass can often be obstructed by reflections shown below.

There are a variety of techniques and tools professional photographers can use to minimize these reflections, however these are often not readily available to the average user. The goal of this project is to explore computational techniques of removing reflections. I will evaluate three separate algorithms to determine the various advantages and disadvantages for each one.

Conclusion

The algorithm using ghosting cues struggled to separate the reflection layer from the transmission layer because it only received a single image as input. It works best with reflections from double-plane windows and even then still requires fine-tuning of the parameters to produce a good separation. SPBS-M produces the best separation with few (< 4) static images as shown in the third result. However, when there is significant movement in the reflections as shown in the 2nd example, the outputs get blurred and the separation is no longer as clean. SID performs very well even with high reflection change, and it is the fastest of the three. However, it struggles with few input images.

[1] K. Gai, Z. Shi and C. Zhang, "Blind Separation of Superimposed Moving Images Using Image Statistics," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 34, no. 1, pp. 19-32, Jan. 2012
[2] Xiaojie Guo, Xiaochun Cao, and Yi Ma. Robust separation of reflection from multiple images. In *Computer Vision and Pattern Recognition (CVPR), 2014 IEEE Conference on*, pages 2195–2202, June 2014.
[3] YiChang Shih, D. Krishnan, F. Durand, and W.T. Freeman. Reflection removal using ghosting cues. In *Computer Vision and Pattern Recognition (CVPR), 2015 IEEE Conference on*, pages 3193–3201, June 2015.
[4] Tianfan Xue, Michael Rubinstein, Ce Liu, and William T. Freeman. A computational approach for obstruction-free photography. *ACM Trans. Graph.*, 34(4):79:1–79:11, July 2015.

Reflection Removal Algorithms

Sparse Blind Separation with Motions (SPBS-M) [1]

Takes in multiple images of a scene with variations in movement, intensities, and reflections. Uses these images to estimate the motion of each layer and the mixing coefficient of each image.

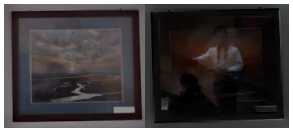
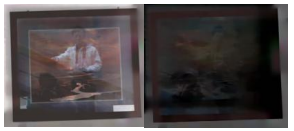
Superimposed Image Decomposition (SID) [2]

Takes in a series of translated photos and exploits the relative motion between the reflected and transmitted layers to separate them.

Ghosting Cues [3]

Takes in a single image input and searches for "ghosting" effects – multiple reflections from the window in the captured image.

Experimental Results

Input Image	SPBS-M		SID		Ghosting Cues	
	Transmission	Reflection	Transmission	Reflection	Transmission	Reflection
						
20 Images 220x200	Elapsed time ~ 15 min		Elapsed time ~ 30 s		Elapsed time ~ 30 min	
						
4 Images 200x180	Elapsed time ~ 1 hr		Elapsed time ~ 20 s		Elapsed time ~ 30 min	
						
2 Images 450x400	Elapsed time ~ 1.5 hrs		Elapsed time ~ 60 s		Elapsed time ~ 4 hrs	