Improved Bilateral Filter using Image Segmentation

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1. Background

- The bilateral filter is an edge-preserving smoothing filter [2]
- Bilateral filtering is used in a multitude of applications, like blurring , enhancing flash photography [1] and more
- The filter uses the spatial distance and the intensity difference between pixels for filtering

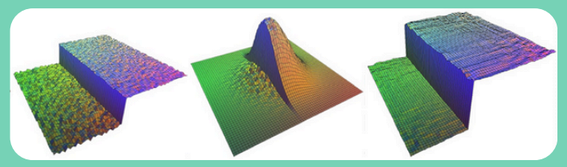

Figure 1: The bilateral filter.

- **Problem:** The bilateral filter blurs with pixels beyond edges if their intensity is close to that of the target pixel

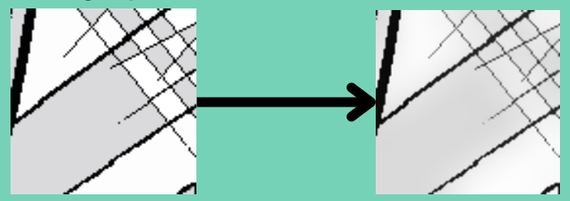

Figure 2: The bilateral filter blurring across edges, creating in between gray levels instead of keeping them the same in each segment.

2. Research Question

Can the bilateral filter be improved by making it aware of the structure in the image to give higher-level control over across-edge blurring?

3. Method

- First we start with finding edges in the image with two types of edge detection: one that produces gradient-like edges and the other creating binary edges
- The edges are then combined by interpolating between them with a user defined ratio
- The new filter then takes these new edges into account for filtering with an extra kernel
- When filtering a pixel, the weight of neighboring pixels is reduced if edges have to be traversed to reach them
- The further a pixel lies beyond an edge, the lower its weight will be
- Choosing more defined edges allows little to no across-edge blurring, softer edges do allow some blur to smooth out the edges themselves

4. Results

Figure 3: The original image

Figure 4: The bilateral filter

Figure 5: The edge-aware bilateral filter using hard binary edges

Figure 6: The edge-aware bilateral filter using a combination of hard and soft edges

Figure 7: The edge-aware bilateral filter using soft gradient-like edges

5. Conclusions

- The edge-aware filter is indeed able to reduce the across-edge blurring of the standard bilateral filter
- The new filter is able to take harder or softer edges into account, resulting in less or more blurred edges
- Images with gradient-like edges need softer edge detection for better results, while images with hard edges need more defined boundaries from the edge detection
- Edges themselves are also preserved better, reducing the washed-out look that the bilateral filter can produce

6. Future work

- The edge-aware filter can easily be extended to also work on color images
- Make the edge-aware bilateral filter more efficient in terms of its runtime, as it is quite computationally expensive
- A better method for edge detection needs to be found that is able to capture more details, so they do not get smoothed out

7. References

[1] E. Eisemann and F. Durand. “Flash photography enhancement via intrinsic relighting”. In: ACM transactions on graphics 23.3 (Aug. 2004), pp. 673–678.

[2] C. Tomasi and R. Manduchi. “Bilateral filtering for gray and color images”. In: Sixth International Conference on Computer Vision (IEEE Cat. No.98CH36271). 1998, pp. 839–846.