Forward-backward diffusion and Pruning-based Cost Aggregation for Non-local Stereo Matching

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Introduction

Minimum spanning tree (MST) has been devised for non-local cost aggregation to solve the stereo matching problem. However, the cost aggregation is employed directly from leaf toward root node, then in an inverse pass without considering any decision rules. And a small amount of noise is also existed in stereo image pairs. Both of the limitations often lead to failure in achieving more competitive results.
This paper presents a novel stereo matching algorithm using forward-backward diffusion and pruning-based cost aggregation. In “forward-backward” process, the raw image pairs are smoothened on a horizontal tree structure as well as retaining image edges sharp. During cost aggregation, the MST where a complete graph involves the whole image pixels is cut off self-adaptively when the depth edge information is referred to. Each node in this tree receives supports from all other nodes which belong to similar depth regions. Meanwhile, an enhanced edge similarity function between two nearest neighboring nodes is formulated to deal with the small-weight-accumulation problem in textureless regions.

Contributions

1) An effective diffusion method for preprocessing of the raw input images; 2) An novel pruning-based method for cost aggregation; 3) An enhanced edge similarity function for small-weight-accumulation problem; 4) Quantitative evaluation with several MST based methods on Middlebury v.2 & v.3 datasets.

Methods

- Forward-backward diffusion is a smoothing method that allows image edges to remain sharp as well as smoothening out noise in raw image pairs.
- The pruning-based decision rule incorporates the local weights and disparity discontinuities, and each node can receive supports from all other nodes belonging to similar depth regions.
- An enhanced edge similarity function between two nearest neighboring nodes is proposed for suppressing the impact of this problem in textureless regions.

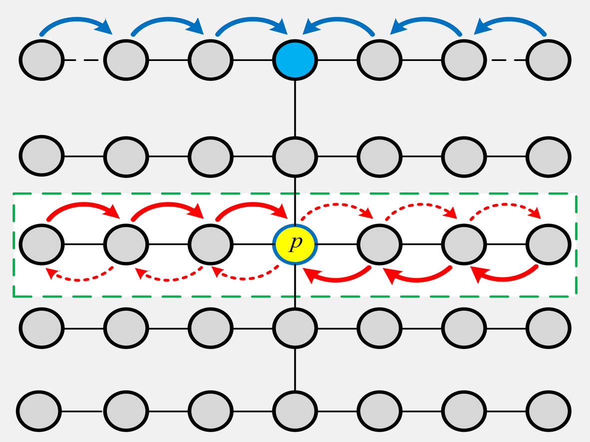
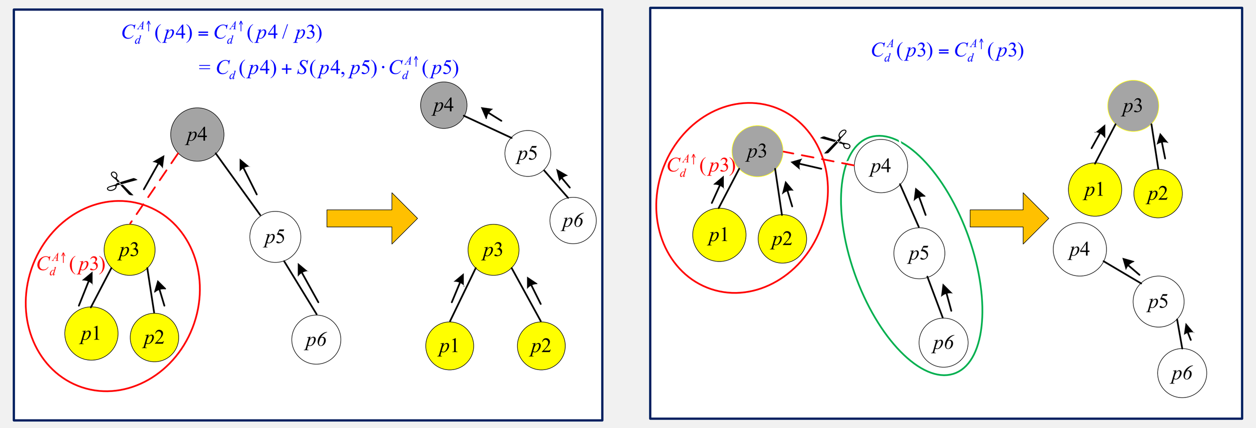


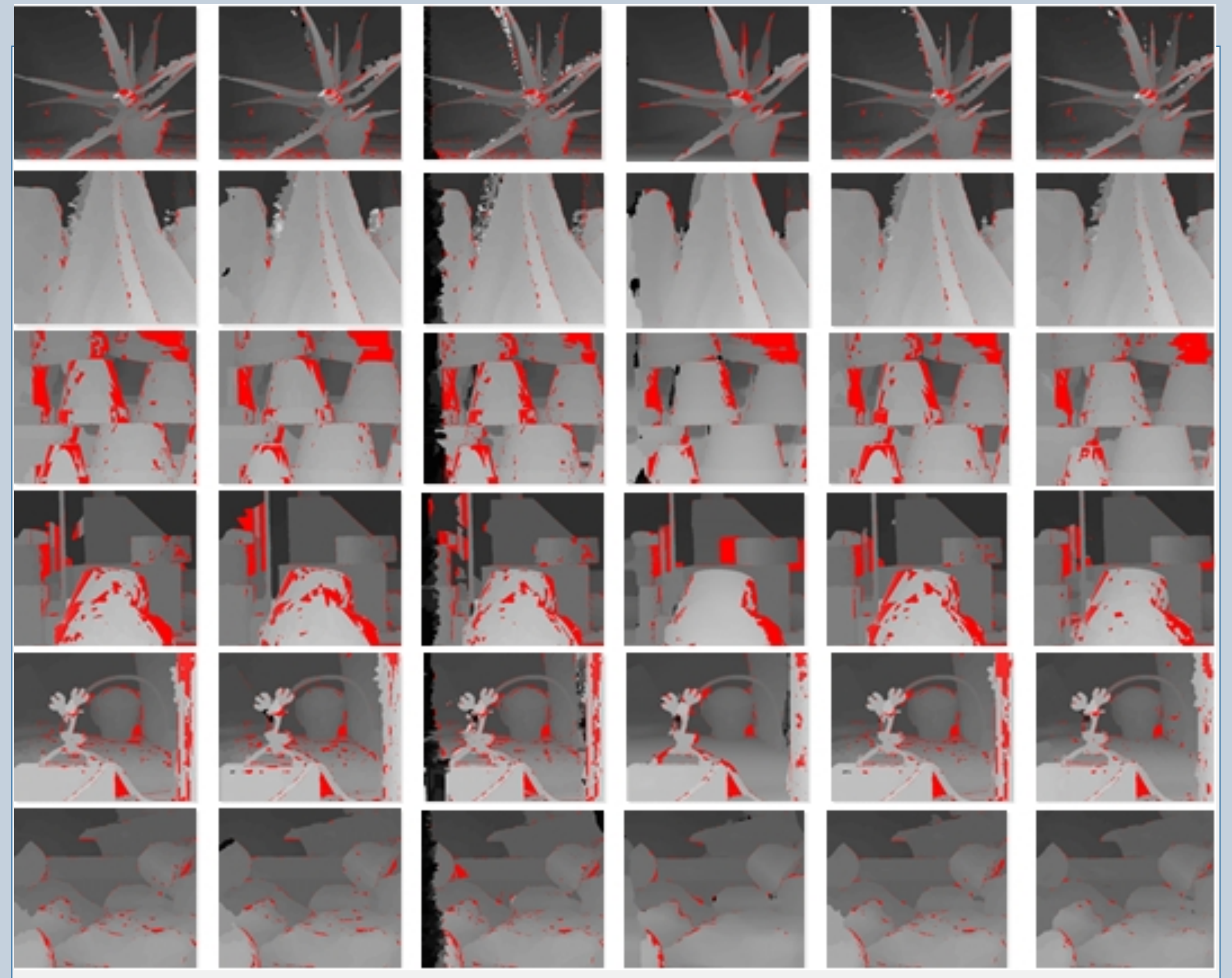
Fig.1. Horizontal tree structure rooted on pixel p.



(a) from leaf to root (b) from root to leaf
Fig.2. Two pruning-based cost aggregation steps

Experimental results

Six representative images pairs (Aloe, Cloth4, Flowerpots, Lampshade1, Reindeer and Rocks1) are selected to show the superior performance of the proposed method visually. The results are shown in Figure 3, where the error pixels in non-occluded regions are marked in red. It can be observed from the disparity maps that the proposed method achieves more accurate disparity maps and reliable image boundaries especially in low-textured regions.



(a) (b) (c) (d) (e) (f)

Fig.3. Disparity maps on Aloe, Cloth4, Flowerpots, Lampshade1, Reindeer and Rocks1 (from top to bottom row) by six different stereo matching algorithms. (a) MST. (b) ST-2. (c) CS-MST. (d) WCPSP. (e) MST-CD2. (f) Proposed method. The error pixels in non-occluded regions are marked in red for each disparity map and the error threshold is 1.0 pixel.

Conclusion

In this paper, a stereo matching algorithm using forward-backward diffusion and pruning-based cost aggregation is proposed. The proposed method is developed with the forward-backward diffusion and the pruning-based cost aggregation as well as the enhanced edge similarity function. The proposed method has some advantages. First, the raw stereo image pairs are smoothened on a weighted horizontal tree structure with “forward-backward” process, it allows depth edges to remain sharp while smoothening out noise. Second, the pruning method is used to cut off the MST structure self-adaptively so that every node receives supports only from similar depth regions. For the sake of suppressing the impact of small-weight-accumulation problem in textureless regions, an enhanced edge similarity function between two nearest neighboring nodes is formulated. Experimental results show that the proposed method could achieve better matching accuracy with a minor cost of increased execution time.