Haar Filter Hardware Architecture for the Accuracy Improvement of Stereo Vision Systems

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Introduction

✓ Stereo Vision System

- A stereo vision system is essential to compute a disparity map for measuring the distance to objects.
- In the stereo vision systems, semi-global matching (SGM) is widely used to compute the disparity map b ecause it has advantages of fast processing speed and high disparity accuracy.
- However, the mismatching can occur frequently by noise and high-frequency components.
- Therefore, to overcome the mismatching problem, we proposed the preprocessing method based on 2-D Haar filter

Proposed Method

✓ Filtering Process

- The input images include left and right-side images acquired by a stereo vision camera.
- A 2-D Haar filter is used to compute the frequency components of the original input image.
- The frequency components consist of low-low (LL), low-high (LH), high-low (HL), and high-high (HH).

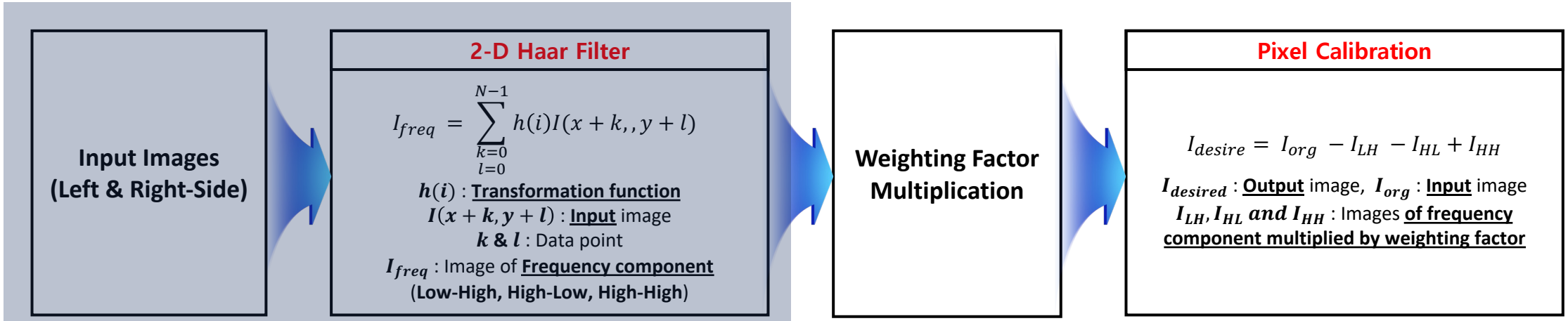


Fig. 1 Proposed preprocessing method

Proposed Method

✓ Calibration Process

- In the calibration process, the three types of frequency component except for LL are used.
- The three types of frequency component are multiplied by weighting factor.
- The three types of frequency component, which are multiplied by weighting factor, are calibrated from the original input image such as for computing the $I_{desired}$.

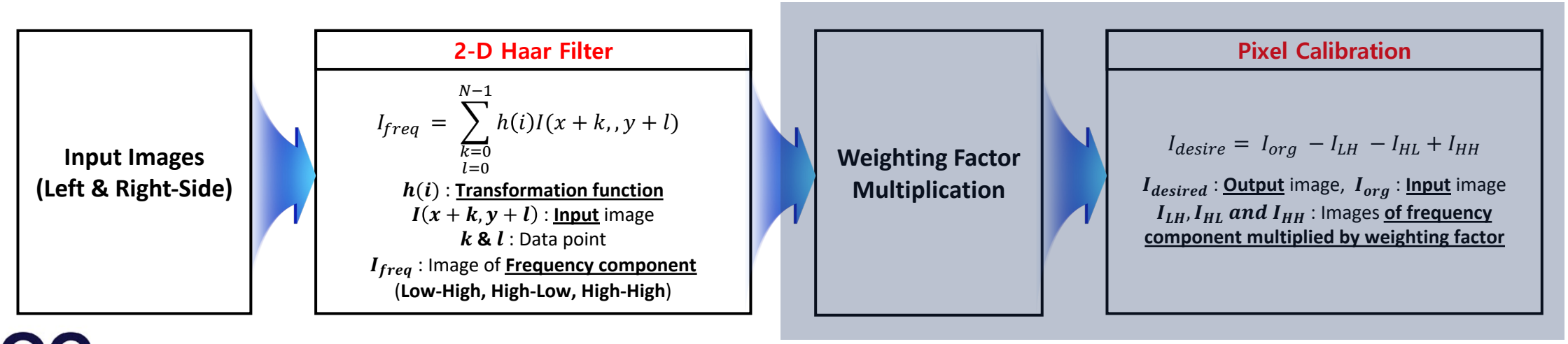


Fig. 1 Proposed preprocessing method

Experiment Results

✓ Public Dataset

- KITTI stereo dataset, which is public test dataset, consists of 200 images
- In the non-occlusion condition, the proposed method reduce the mean error rate by 3.52% compared with Gaussian filter.
- In the occlusion condition, the proposed method reduce the mean error rate by 3.26% compared with Gaussian filter

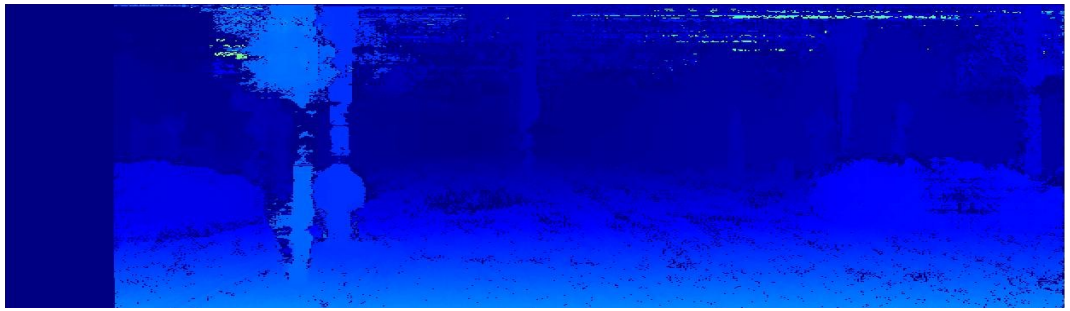
	Non-Occlusion		Occlusion	
	Mismatching Pixels	Mean Error Rate	Mismatching Pixels	Mean Error Rate
Gaussian	104704	22.48%	111007	23.83%
Proposed	**101015**	**21.69%**	**107383**	**23.06%**
Improvement	**3.52%**	-	**3.26%**	-

Table. 1 Performance comparison

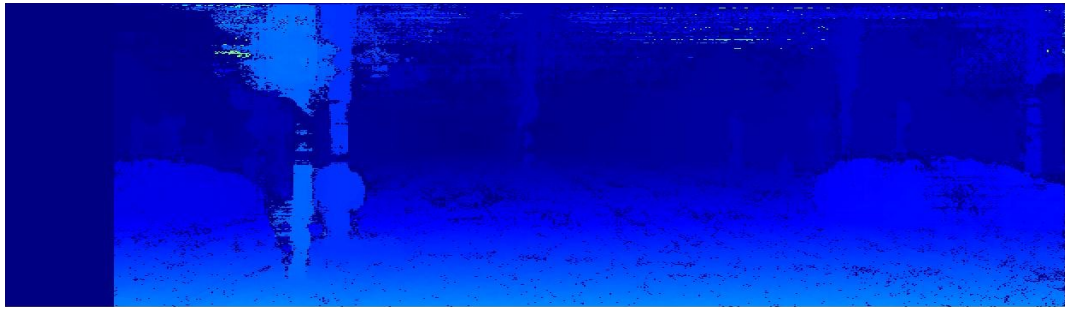
Experiment Results

✓ **Public Dataset**

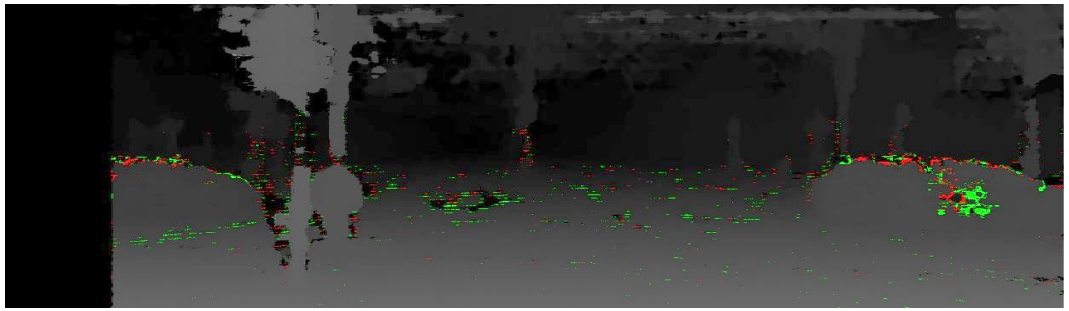
- It shows the disparity map results of sample image from the KITTI test dataset.
- (a) is the result of applying the Gaussian filter.
- (b) is the result of applying the proposed method.
- (c) is the comparison result between the proposed method and the Gaussian filter.
- In the (c), the green color indicator is improvement, and red color indicator is deterioration.



(a) Gaussian Filter



(b) Proposed Method



(c) Comparison Result

Figure 1. Results of Disparity Map

Experiment Results

✓ Hardware Resource

- The slice LUT and slice register of the proposed method slightly increased compared with Gaussian filter
- The BRAM of proposed method was smaller than that of the Gaussian filter.
- Overall, the hardware resource usage of the proposed method is similar to that of the Gaussian filter

Resource	Gaussian Filter	Propose Method
Slice LUTs	110	**137**
Slice Registers	180	**191**
BRAMs	2	**1**

Table. 2 Hardware resource usage

Conclusion

✓ Conclusion

- The proposed method improves the matching accuracy of SGM with reasonable hardware resource usages.
- Therefore, it is suitable for embedded systems require high matching accuracy.
- In the future work, we will utilize and implement the Daubechies wavelet family filter for the proposed method of this paper to improve the matching accuracy.