Chapter 36
Hybrid Performance with Pixel Values' Transition and Curve Fitting for Improved Stereo Matching

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Abstract We propose method that it can get disparity values uniformly even though the targeted stereo images is distorted by particular effects of illumination. The proposed method has key feature. This doesn't perform additional process as like preprocessing. That is, this has robust performance about distortion occurred through external illumination and carmera parameters. As a result, we could derive the maximum hybrid performance. The verification was showed by the good subjective and objective evaluations result.

36.1 Introduction

The stereo matching makes people cubic effects that it uses binocular disparity of human [1–5]. So the key point of stereo matching is to extract disparity information of images. In details, there are relatively different movement differentials between background and foreground objects in stereo images. We can exploit this point enough. That is, the background with long distant from camera view point gets small disparity value as the movement differential is short. On the other hand, the foreground objects with short distant from camera view point gets relatively large disparity value. If we get somewhat precise disparity value, also we can calculate depth information through evenly gray-level scaling.

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The acquisition of stereo images put to use particular stereo camera. Whereas it can be to happens external effects as like illumination. And then it is considerably hard to acquire precise disparity values. Ordinarily the illumination distortion is occurred by absolute illumination and camera parameter values' difference.

In this paper, we have emphasis on the negative effect of absolute illumination difference. We propose method that it can get disparity values uniformly even though the targeted stereo images is distorted by particular effects of illumination. The proposed method has key feature. This doesn't perform additional process as like preprocessing. That is, this has robust performance about distortion occurred through external illumination and camera parameters. More in details, firstly, we exploit delicately pixel values' transition in particular block-based window. In other words, we could call as the observation of subtle changes. Next, we exploit curve fitting in particular block-based window for more improved stereo matching result. Again, we could call as the observation of coarse changes. As a result, we could derive the maximum hybrid performance.

This paper are organized as follows. Section 36.2 reviews the prominent stereo matching introduced previously. STEP I: Getting of Pixel Values' Transition State and STEP II: Adoption of Curve Fitting for More Improved Performance are presented in Sect. 36.3. Experiments and performance results are presented in Sect. 36.4. Finally, concluding remarks and future works were descripted in Sect. 36.5.

36.2 The Prominent Stereo Matching introduced Previously

36.2.1 Adaptive Support Weight (ASW) [6]

The ASW exploits weight values which uses color and distance information. And then this finds responding area in stereo matching. This method has roughly higher performance than SAD, SSD etc. But this method tends to centralize color's similarity. Consequently, it had weakness when the distortion is occurred with external factors as illumination related with color and camera parameters. That is, we couldn't acquire more precise disparity values. Eq. (36.1) is to represent ASW method with formal expression. We hope that it is to be referred for understanding.

$$w(p,q) = \exp\left(-\left(\frac{\Delta C_{pq}}{\Upsilon_c} + \frac{\Delta g_{pq}}{\Upsilon_p}\right)\right) \tag{36.1}$$

36.2.2 Adaptive Normalized Cross Correlation (ANCC) [7, 8]

The ANCC performs preprocessing as like Gamma value correction, normalization of Log-chromacity Color. The processes as like these need to minimize

unnecessary illumination's effects. Consequentially, this preprocessing causes precise stereo matching results. The method exploits basically weight values which uses color and distance information. In this aspects, we could regard that this method is similar to ASW.

$$ANCC_{logChrom\_R}(f_p) = \frac{\sum_{i=1}^{M} w_L(t_i) w_R(t_i) \left[R_L'''(t_i)\right] \times \left[R_R'''(t_i)\right]}{\sqrt{\sum_{i=1}^{M} |w_L(t_i) R_L'''(t_i)|^2} \times \sqrt{\sum_{i=1}^{M} |w_R(t_i) R_R'''(t_i)|^2}} \quad (36.2)$$

Equation (36.2) is to represent ANCC method with formal expression. This method could decide the responding region with mechanism of this expression and support to select the responding region with help of weight. R_L''' and R_R''' are reprocessed pixels information of both windows for protection of fattening effects the preservation of edges. Through above processes, the ANCC method could extract uniform disparity values in redundant illumination's changes.

36.3 The Hybrid Method with Pixel Values' Transition and Curve Fitting

36.3.1 STEP I: Getting of Pixel Values' Transition State

Most images have analogous color information in neighborhood pixels. It is same despite of being effected by overall illumination. So, the difference between particular pixel and neighborhood pixel values would be analogous if it is responding region. Our method start at simple and intuitive idea. Figure 36.1 depicts STEP I: Getting of pixel values' transition state. We hope to refer Fig. 36.1 about specific processes.

Figure 36.2 depicts getting algorithm of pixel values' transition state with simple expression. Particularly, in this figure, the left image shows existing window and the right image shows window moved to arrow direction. That is, this figure shows whole flow of method performance.

In Fig. 36.2, the sum of difference value between A−B and A′−B′ and difference value between C−D and C′−D′ is calculated in direction of left and right. The sum of difference value between A−C and A′−C′ and difference value between B−D and B′−D′ is calculated in direction of up and down.

$$\begin{aligned} &\sum_{(i,j)\in W} (|I_1(i,j) - I_1(i,j+1)| - |I_2(i,j) - I_2(i,j+1)|) \\ &+ \sum_{(i,j)\in W} (|I_1(i,j) - I_1(i+1,j)| - |I_2(i,j) - I_2(i+1,j)|) \end{aligned} \quad (36.3)$$

Equation (36.3) expresses STEP I with the formal expression. In this equation, i and j mean the coordinate of pixel, w means window and I_1 means left image and

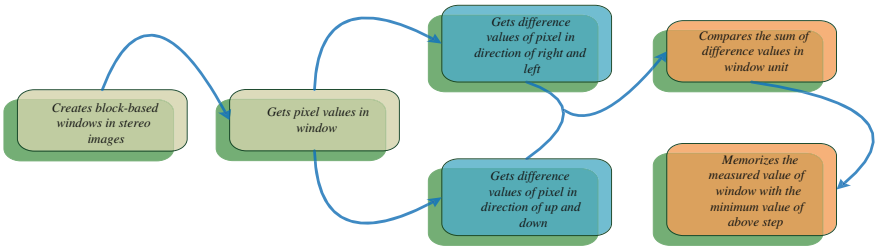
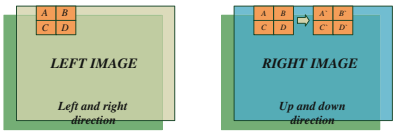


Fig. 36.1 Getting processes of pixel values' transition state



$$\min[(|A-B|-|A'-B'|)+(|C-D|-|C'-D'|)+(|A-C|-|A'-C'|)+(|B-D|-|B'-D'|)]$$

Fig. 36.2 Getting algorithm of pixel values' transition state with simple expression

I_2 means right image. Whereas, occasionally we couldn't find out precise disparity values in edge regions. In that case, it might be excess of native maximum disparity values or 0's disparity value. This is because of using only neighborhood pixel information while it doesn't includes comprehensive changes in block-based window. We adopted additionally curve fitting method for reflecting overall change of window.

36.3.2 STEP II: Adoption of Curve Fitting for More Improved Performance

The curve fitting finds out the most adjacent curve using given coordinates' information. It is represented by formal polynomials.

Figure 36.3 depicts STEP II: Adoption of curve fitting for more improved performance. We hope to refer Fig. 36.3 about specific processes.

If the curve fitting is performed in the region of left window, particular polynomial expression is created. We store all the coefficients. Next, we set window in right image based window's position in left image. And then we move as search range and perform curve fitting about right window. The polynomial expression obtained as like this is comparable polynomial expression of left window. We could get the difference of coefficients between the most degrees. And we decide as responding region that it has the most minimum difference of relevant coefficient. As a result, this method could show the overall pixels change of in-window.

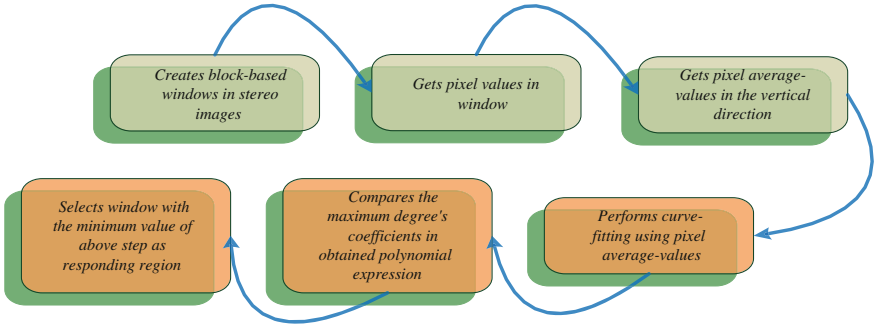


Fig. 36.3 Adoption processes of curve fitting

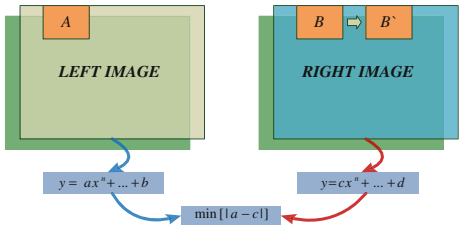


Fig. 36.4 Adoption algorithm of curve fitting

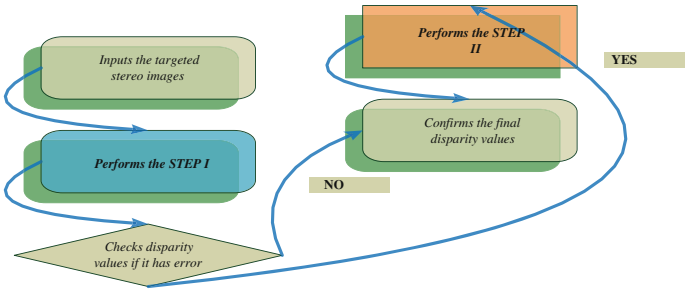


Fig. 36.5 The hybrid method with pixel values' transition and curve fitting

Therefore we could select the more precise responding region. Figure 36.4 depicts simply adoption algorithm of curve fitting.

36.3.3 The Final Algorithm of Proposed Method

Figure 36.5 depicts the hybrid method with pixel values' transition and curve fitting. That is, this figure shows the final algorithm of proposed method.

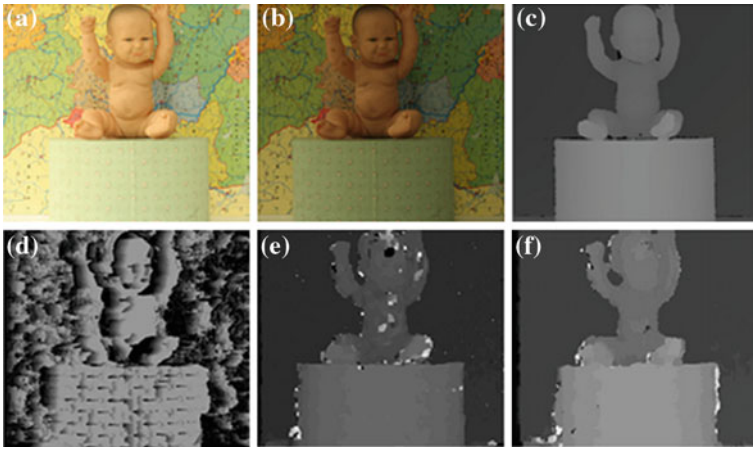


Fig. 36.6 The Baby1 in stereo images

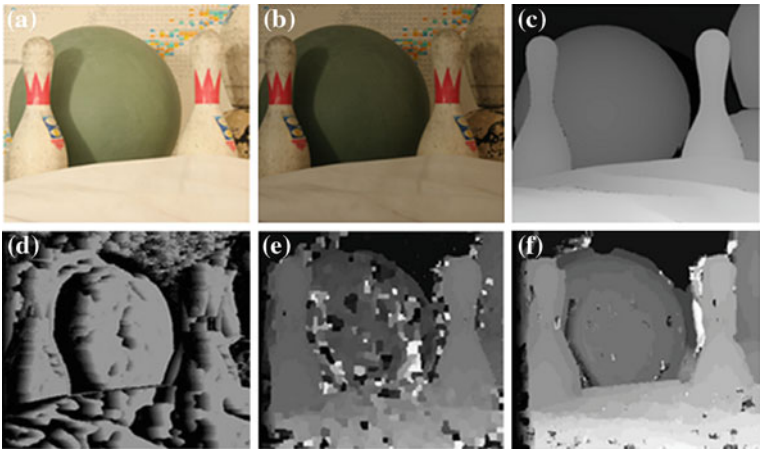


Fig. 36.7 The Bowling1 in stereo images

36.4 The Experiments and Performances

36.4.1 The Experiments Environment

The window size is 11 × 11 in pixel unit. The experiments images' source is Middlebury Studio [9]. The comparison group includes ASW and ANCC and targetted testing stereo images are Baby1, Bowling1, Flowerpots. We performed the subjective and the objective evaluations to increase experiments' reliability.

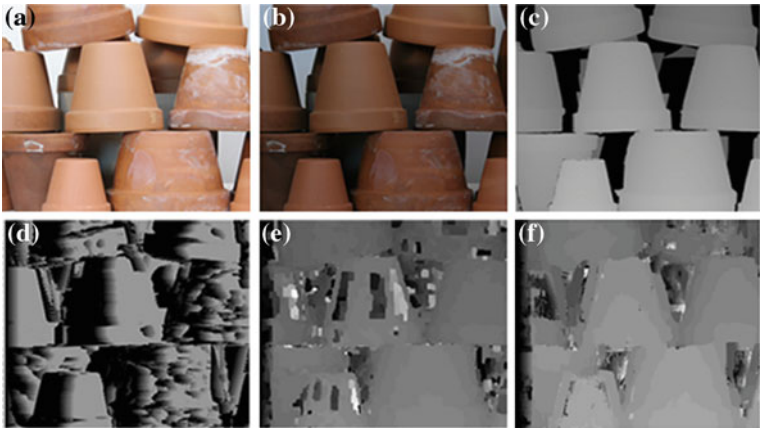


Fig. 36.8 The Flowerpots in stereo images

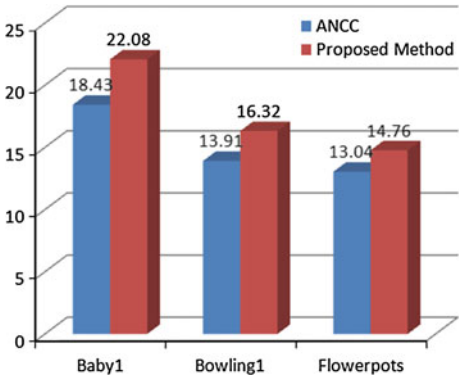


Fig. 36.9 The PSNR numerical values' comparison with Baby1, Bowling1, Flowerpots

36.4.2 The Subjective Evaluations

Figure 36.6 describes the Baby1 in stereo images with different illumination values. As you see, we could verify that the proposed method has more clear, precise disparity image compared with ASW, ANCC. Figure 36.7 describes the Bowling1 in stereo images with different illumination values. As you see, we could verify that the proposed method has more clear, precise disparity image compared with ASW, ANCC. Figure 36.8 describes the Flowerpots in stereo images with different illumination values. As you see, we could verify that the proposed method has more clear, precise disparity image compared with ASW, ANCC.

36.4.3 The Objective Evaluations

Figure 36.9 depicts the PSNR numerical values' comparison with Baby1, Bowling1, Flowerpots. As you see, the proposed method precedes in aspect of PSNR numerical values. ANCC method's PSNR average value is 15.33 and the proposed method is 17.72. Consequently, the method of this paper is about 17 % higher than ANCC method.

36.5 Conclusions and Future Works

We propose method that it can get disparity values uniformly even though the targeted stereo images is distorted by particular effects of illumination. The proposed method has key feature. This doesn't perform additional process as like preprocessing. That is, this has robust performance about distortion occurred through external illumination and camera parameters. As a result, we could derive the maximum hybrid performance. In experiments performed previously, we could confirm through relatively superior result compared with typical local stereo matching. Moreover, the experiment methods include the subjective and objective evaluation comprehensively. But we think that the experiments testing quantity is insufficient. We are ongoing additional verification as future works.

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