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애너글리프 영상을 이용한 깊이 영상 취득과 채색 기법

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초록: This paper presents a joint iterative anaglyph stereo matching and colorization framework to obtain a set of disparity maps and colorized images. We utilize AANCC based stereo matching algorithm to compute the correspondence of anaglyph image. To colorize the anaglyph image, each pixel in one view is warped to another view using the obtained disparity values of non-occluded regions. Then, colorization algorithm using optimization is utilized with a novel weight kernel function to colorize the remaining colors of occluded regions. Experimental results confirm that the unified framework is robust and gives accurate results of both depth maps and colorized stereo images.

주제어: anaglyph image, colorization, optimization

Ⅰ. Introduction

During the last few decades, 3D technology has become popular in research activities as well as consumer usages. One of the examples is an anaglyph image which has been used to visualize 3D scenes so that users can feel 3D experience by wearing a color filtered glasses. An anaglyph image contains partial information of stereo images, which usually consists of red color (only red channel) from the left image and cyan color (blue and green channels) from the right image. Consequently, the usage of anaglyph image leads to missing color information. Therefore, it is difficult to process the anaglyph image using conventional computer vision algorithms. In the beginning phase of anaglyph computer vision, several works have been done to colorize the pixels in the missing channels of the anaglyph image [2,3]. However, the state-of-the-art in anaglyph colorization problem [2], which utilizes the modified SIFT Flow and diffusion algorithm [4] to reconstruct the missing color in an anaglyph image, still fails when the stereo pair has large disparity correspondences, object with a single dominant color, or complex scenes.

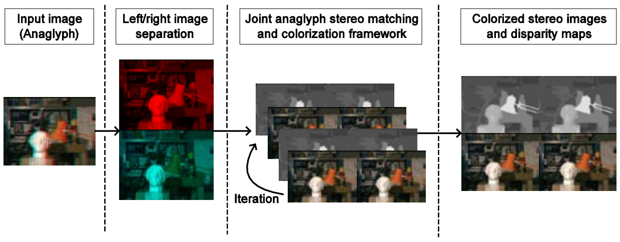

Fig 1. Pipeline of the proposed algorithm.

In this paper, we propose an iterative joint method to not only compute the disparity map but also colorize the missing color information of an anaglyph image simultaneously. The problem to be solved is a kind of chicken and egg problem because there exists strong dependency between each individual problem. An accurate disparity result is required to achieve a good colorization result while a correctly colorized stereo pair is required to compute an accurate disparity map. Therefore, we consider solving both problems simultaneously in an iterative framework. The overview of the proposed framework is shown in Fig. 1.

Ⅱ. Iterative Framework for Anaglyph Stereo Matching and Colorization

We solve an energy minimization problem with an Absolute Adaptive Normalized Cross-Correlation (AANCC) for the anaglyph data cost to compute the stereo correspondences of the anaglyph image [1]. Anaglyph colorization is performed using the obtained disparity values of non-occluded regions. First, left-right consistency check is performed to find the occluded regions in both images. Each pixel from the known color channel is warped to another image using the disparity map. Note that the pixels in occluded regions are not warped because they do not exist in the correspondence image. However, the erroneous disparity values still lead to incorrect colorization. Therefore, color consistency check is performed set the incorrect colorized pixel with undetermined color flag. The color consistency check for left image is defined as follows.

$$I^L_{\{G,B\}}(p)=\begin{cases}0 & \Delta_{rgb}(p,p+d(p))>0\\ I^L_{\{G,B\}}(p) & otherwise\end{cases}$$

where $\Delta_{rgb}(p,p+d(p))$ is the RGB color difference between a pixel p with its correspondence pixel $p+d(p)$. If the RGB color difference is not zero, then the colorized pixel in the left and right images are set to have undetermined color flag. The color consistency check for the right image is performed similarly.

To colorize the remaining pixels with undetermined color flag, we propose a novel weight kernel function which improves Levin's colorization algorithm [4]. For each pixel in occluded regions, we compute the most similar patch (5×5) in a designated window. Template matching is utilized to find the most similar patch. Then, the energy function is defined as follows.

$$J(R)=\sum_p\left(R(p)-\theta\sum_{t\in N(p)}w_{p,t}R(t)-\sum_{t\in M(p)}w_{p,t}R(t)\right)^2$$

where $R(p)$ is the value of pixel p in color channel that will be colorized and $w_{p,t}$ is the weight between pixel p and t. The weight $w_{p,t}$ is only computed for pixels inside a local window (7×7). $M(p)$ is a (3×3) window of the most similar patch to a patch of pixel p. θ is the regularization parameter. To minimize $J(R)$, we use a least square solver for sparse linear systems. The additional constraint is performed well when the obtained disparity maps have good quality. Therefore, it is utilized only in the last iteration of colorization method because the disparity maps in the initial iteration might lead to erroneous colorization results.

Ⅲ. Experimental Results

To evaluate the accuracy of the anaglyph colorization, the proposed framework is compared with Joulin's algorithm [2] and Lin's algorithm [3]. Fig. 2 shows the visual comparison and the difference maps of the colorized images. It is clearly shown that the proposed algorithm obtains significantly smaller error compared with other conventional approaches. PSNR value is computed for each image to compute the error quantitatively, which is summarized in the figure caption.

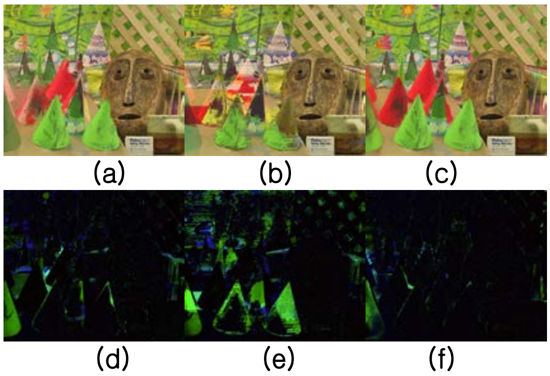

Fig 2. Colorization results comparison between the proposed framework and the conventional methods (Cones dataset). (a) Results of Lin [3] (PSNR: 18.12 dB); (b) Results of Joulin [2] (PSNR: 21.52 dB); (c) Results of the proposed method (PSNR: 26.62 dB); (d) Difference maps of Lin [3]; (e) Difference maps of Joulin [2]; (f) Difference maps of the proposed method;

Ⅳ. Conclusion

In this paper, we proposed an iterative framework for anaglyph stereo matching and colorization. In addition, we proposed a novel weight function used for colorization. It is shown that the proposed framework could achieve better colorization results compared to conventional approaches.

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