H-029

Study of Optimizing the Parameters in the Weighted Histogram Equalization for Stereoscopic Enhancement

Xiao Ding † Jun Ohya † Takashi Kawai† Nobuaki Abe†

1. Introduction

Many 3D (stereoscopic) display systems have been developed. However, 3D sense cannot always be sufficiently presented. If the texture of the displayed 3D object is reasonably enhanced, the sense of 3D might be enhanced also. This paper deals with contrast enhancement useful for stereoscopic displays.

Conventional contrast enhancement technologies mainly dealt with gray-level and color contrast enhancements. Many contrast enhancement methods were proposed. For instance, Thomas et al.[1] proposed an enhancement method by considering the correlation between the luminance and saturation components of the image locally and Shyu et al. [2] suggested a genetic algorithm approach in which the enhancement problem is formulated as an optimization problem.

The related research mentioned above and some relational work[3]-[7] is useful for color image enhancement. However, 3D sense is not so much considered. Actually, not many works on the 3D contrast enhancement can be seen. This paper has proposed a stereoscopic contrast enhancement method based on local gray-level contrast and range information. The research is to enhance the 3D sense of color images so as to make it more vivid. We focus on the distance (range), an important element of 3D sense in displaying digital contents. According to the feature of human vision, near areas from the viewpoint tend to be visible clearly while far areas tend to be visible not clearly. Our basic strategy is to enhance the contrast of low-contrasted near areas and suppress the contrast of high-contrasted far areas so as to enhance the distance sense. Experiments using a stereoscopic display show that the proposed method works better than the conventional histogram equalization and restores degraded images well. The following section elaborates on the specific algorithm and some discussion of parameter optimizing of our proposed method.

2. Approach

Our proposed method consists of the following six steps:

1. Obtain original RGB image and range image
2. Convert RGB to HSV
3. Compute local contrast
4. Compute weight
5. Gray-level conversion based on weighted histogram equalization (WHE)
6. Convert HSV to RGB

We obtain the gray-level image (from the original color image by converting RGB color space to HSV color space) and range image (each pixel of which stores the distance to viewpoint from that pixel) of an object from its 3D data, originally acquired by a range scanner and then edited by 3DS Studio MAX (Fig. 1).

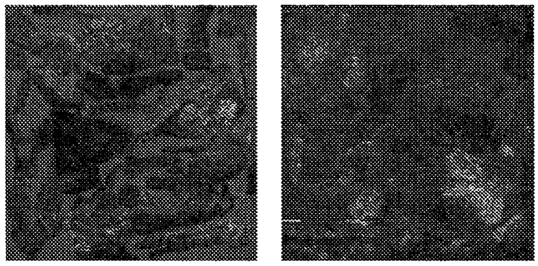

Fig.1 Texture files

The distance value of each pixel in the range image is rendered by gray-levels: the larger the distance value of a pixel is, the darker its gray-level is. The pixels in the background in the range image are set to black so as to easily extract the object from the background (Fig.2).

Fig.2 Original RGB image and range image

At each pixel in the object area in the gray-level image, the local contrast C is computed for the V (in the following, gray-level) component in its local area such as a 5*5 pixel neighborhood area [8]. Then, the weight for each pixel is computed with the local contrast C and distance (range) information D.

$$W = F(D,C) \qquad (1)$$

Then, the weighted histogram of the pixels is constructed and equalized with Eq(2)-(6).

Suppose that the gray –level range is [a, b]. Let Nk be the total weight of the pixels whose gray-level value is k:

$$Nk = \sum_{p:\ \text{pixels with grey-level } k} Wp \qquad (2)$$

Let N be the total weight of the pixels in the image:

$$N = \sum_{k=a}^{b} Nk \qquad (3)$$

For each input gray-level Vi ϵ [a, b], a temporary output Vs (ϵ [a, b]) is computed by Eq.(4):

$$Vs = a + \frac{b-a}{N} \sum_{j=0}^{Vi} Nj \qquad (4)$$

The output gray-level Vo at each pixel is computed by Eq.(5).

$$Vo = Va + (Vs - Va) * W \qquad (5)$$

where Va is the average gray-level of the object. Let M be the number of pixels in the object. Va can be computed with Eq.(6):

$$Va = \frac{1}{M} \sum_{p=1}^{M} Vp \qquad (6)$$

After processing, convert enhanced HSV value of each pixel back to RGB color space.

† Waseda University, Graduate School of Global Information and Telecommunication Studies (GITS)

3. Parameter Optimizing

The method to compute weight in Fig.(1) is modeled as Fig.(7).

$$F(D,C) = \alpha - \beta D - \theta C \qquad (7)$$

For the experiment, we use the RGB and range image for the object shown in Fig. 2, the other is an object of elephant. The range of the distance D is [0, 1], where 0 and 1 correspond to the distance between the nearest and farthest points in the object, respectively.

To test the performance of our proposed method, we degrade the contrast of the original image with 2D Gaussian blurring and apply the proposed method to the degraded image. Using a 3D video displayer, we compare the original image with the result of enhancing the contrast of the degraded image.

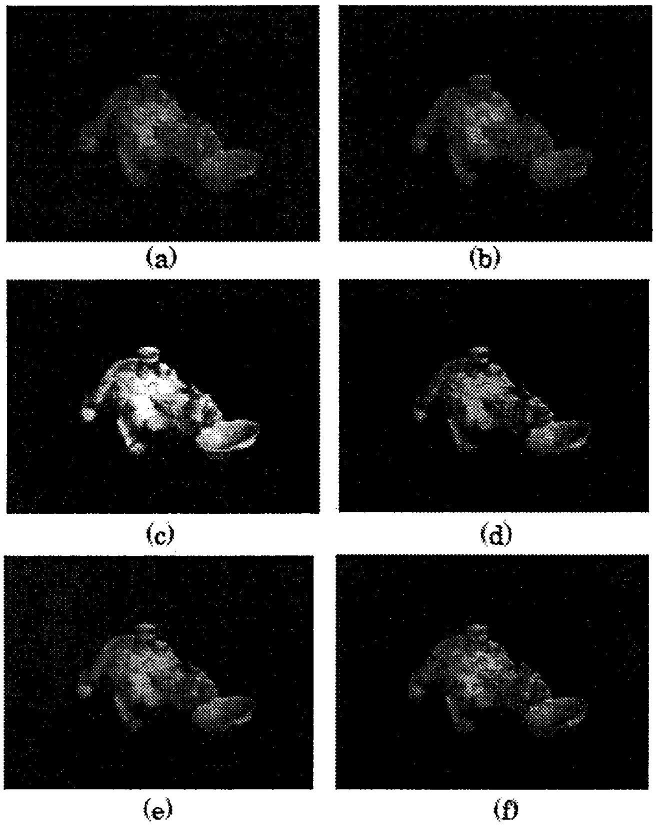

Fig.3 Experimental result

Figure 3 shows the experimental result. In Figure 3, (a) is the original image, (b) is the degraded image, (c) is the result by the conventional histogram equalization, and (d)(e)(f) is the result by our method with different values for the constants α, β and θ. Detailed value is shown in Figure 4.

	α	β	θ
(d)	1	0.8	0.3
(e)	1	0.4	0.8
(f)	1	0.4	0.3

Fig.4 Parameter

As can be seen in Fig. 3, our method can achieve more natural and smoother result than the conventional HE. As a result of observing in the 3D display, it turns out that our method can restore the contrast of the original image very well. Compare the result (d) (e) (f) of proposed method, (d) sets a large β, which gives a larger weight to distance and (e) sets a large θ which gives a larger weight to contrast. The results are both effective but not very good while compared with (f), which gives a balanced weight to both distance and distance.

4. Conclusion and Remaining Issues

This paper has proposed a stereoscopic contrast enhancement method based on local contrast and distance information. We construct a weighted histogram based on local contrast and distance of each pixel. After equalizing the weighted histogram, another conversion that can reflect the weight of that pixel is performed.

Experimental results using a stereoscopic display show that the proposed method can work better than the conventional histogram equalization. It turns out that the proposed method can restore the contrast of the degraded image. From the comparison result of parameters, contrast and distance, which is balanced considered, gave the best performance.

There are also some remaining issues. The model of computing weight is to be improved, and our method should be applied not only for the gray-level component but also color components such as hue and saturation with some adaptive method

References

[1] B. A. Thomas, R. N. Strickland, & J. J. Rodriguez, *Color image enhancement using spatially adaptive saturation feedback*, Proc. 4th IEEE Conf. on Image Processing, Santa Barbara, CA, USA, 30-33, 1997.

[2] M. S. Shyu, & J. J. Leou, *A genetic algorithm approach to color image enhancement*, International Journal of Pattern Recognition, 31(7), 871-880, 1998.

[3] A. Toet, *Multiscale color image enhancement*, Pattern Recognition Letters, 13(2), 167–174, 1992.

[4] Lu J, Hearly D M. *Contrast Enhancement via Multi-scale Gradient transformation,* Proceedings of SPIE: Wavelet Application, Orlando, USA, 345-365, 1994.

[5] Brown T J. *An Adaptive Strategy for Wavelet Based Image Enhancement*, Proceedings of Irish Machine Vision and Image Processing Conference, Belfast, Northern Ireland, 67-81, 2000.

[6] V. Buzuloiu, M. Ciuc, R. M. Rangayyan, & C. Vertan, *Adaptive neighborhood histogram equalization of color images*, International Journal of Electron Image, 10(1), 445-459, 2001.

[7]P. E. Trahanias, & A. N. Venetsanopoulos, *Color image enhancement through 3-D histogram equalization*, Proc. 11th IAPR Conf. on Pattern Recognition, The Hague, Netherlands, 545-548, 1992.

[8] Y.Kobayashi & T.Kato, *A high fidelity contrast improving model based on human vision mechanism*, Proc.IEEE ICMCS'99, 578-584, June 1999.