IEIE Transactions on Smart Processing and Computing

Flickering Effect Reduction Based on the Modified Transformation Function for Video Contrast Enhancement

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Received February 20, 2014; Revised April 20, 2014; Accepted August 28, 2014; Published December 31, 2014

* *Regular Paper*

* *Extended from a Conference: Preliminary results of this paper were presented at the IEIE fall conference 2014. This present paper has been accepted by the editorial board through the regular reviewing process that confirms the original contribution.*

Abstract**:** This paper proposes a method that reduces the flickering effect caused by A-GLG (Adaptive Gray-Level Grouping) during video contrast enhancement. Of the GLG series, A-GLG shows the best contrast enhancement performance. The GLG series is based on histogram grouping. Histogram grouping is calculated differently between the continuous frames with a similar histogram and causes a subtle change in the transformation function. This is the reason for flickering effect when the video contrast is enhanced by A-GLG. To reduce the flickering effect caused by A-GLG, the proposed method calculates a modified transformation function. The modified transformation function is calculated using a previous and current transformation function applied with a weight separately. The proposed method was compared with A-GLG for flickering effect reduction and video contrast enhancement. Through the experimental results, the proposed method showed not only a reduced flickering effect, but also video contrast enhancement.

Keywords**:** Image enhancement, Video contrast enhancement, Histogram modification, Flickering effect reduction, Gray level grouping

1. Introduction

Contrast enhancement is one of the important roles in image processing applications. Generally, poor contrast effects, in which an image may lose detailed information, such as sharpened edges and distinct patterns, and may exhibit a washed-out and unnatural appearance. Because poor contrast is caused by a limitation of the dynamic range, contrast enhancement techniques have been developed to improve the dynamic range of the image/video.

A contrast enhancement technique is categorized into direct and indirect methods. Direct methods define a contrast measure and improve it, whereas indirect methods improve the contrast by exploiting the under-utilized regions of the dynamic range. Most contrast enhancement methods fall into an indirect group. The indirect methods are decomposed into i) an image into high and low frequency signals for manipulation, ii) histogram modification techniques and iii) transform-based techniques. Of these three subgroups, histogram modification techniques have received the most attention because of their straightforward and intuitive implementation qualities [1].

Chen et al. introduced GLG (Gray-level Grouping), which is one of the famous histogram modification techniques for a single image [2, 3]. GLG groups bins according to the value in a histogram and distributes an equal range to each group through the total dynamic range. Grouping phase complements over-enhancement, such as the drawback of histogram equalization and improves a section that is difficult to enhance using a contrast stretching technique. In addition, Chen et al. introduced FGLG (Fast Gray-level Grouping) and A-GLG (Adaptive

Gray-level Grouping). In video contrast enhancement, however, the GLG series has the same problem, a heavy flickering effect. This paper proposes the method to reduce the flickering effect by GLG series during video contrast enhancement. A-GLG was used for the base technique of the proposed method because the result of the performance of A-GLG is the best of the GLG series [2]. Yang et al. [4, 5] proposed a method for flickering effect reduction in FGLG and also proposed the method for reducing the excessive contrast enhancement in A-GLG. This paper proposes a flickering effect reduction method for A-GLG by extending the previous method.

2. Flickering effect analysis

A-GLG performs contrast enhancement for a single image. A-GLG calculates the transformation functions from each frame using the histogram grouping of each sub-image. The calculation of the transformation functions is sensitive to result of the histogram grouping and the result of the histogram grouping differs subtly at each frame. As a result, each transformation function from continuous frames is slightly different, which causes a flickering effect.

Humans can sense flickering sensitively at a silent region that does not have patterns and motions. During video contrast enhancement, humans generally tend to sense a flickering effect if the average difference of a silence region in continuous frames is greater than 5. To understand the effects of a calculation of a transformation function by the histogram grouping 1 group was reduced from an initial 256 groups to 2 groups at a time and make a transformation function at each group.

Fig. 1 shows the difference in the transformation functions by the histogram grouping of GLG. (a) is a uniform histogram and (c) is a histogram changed randomly. (b) is the transformation function calculated by (a), and (d) is calculated by (c). In Fig. 1, g of (b) and (d)

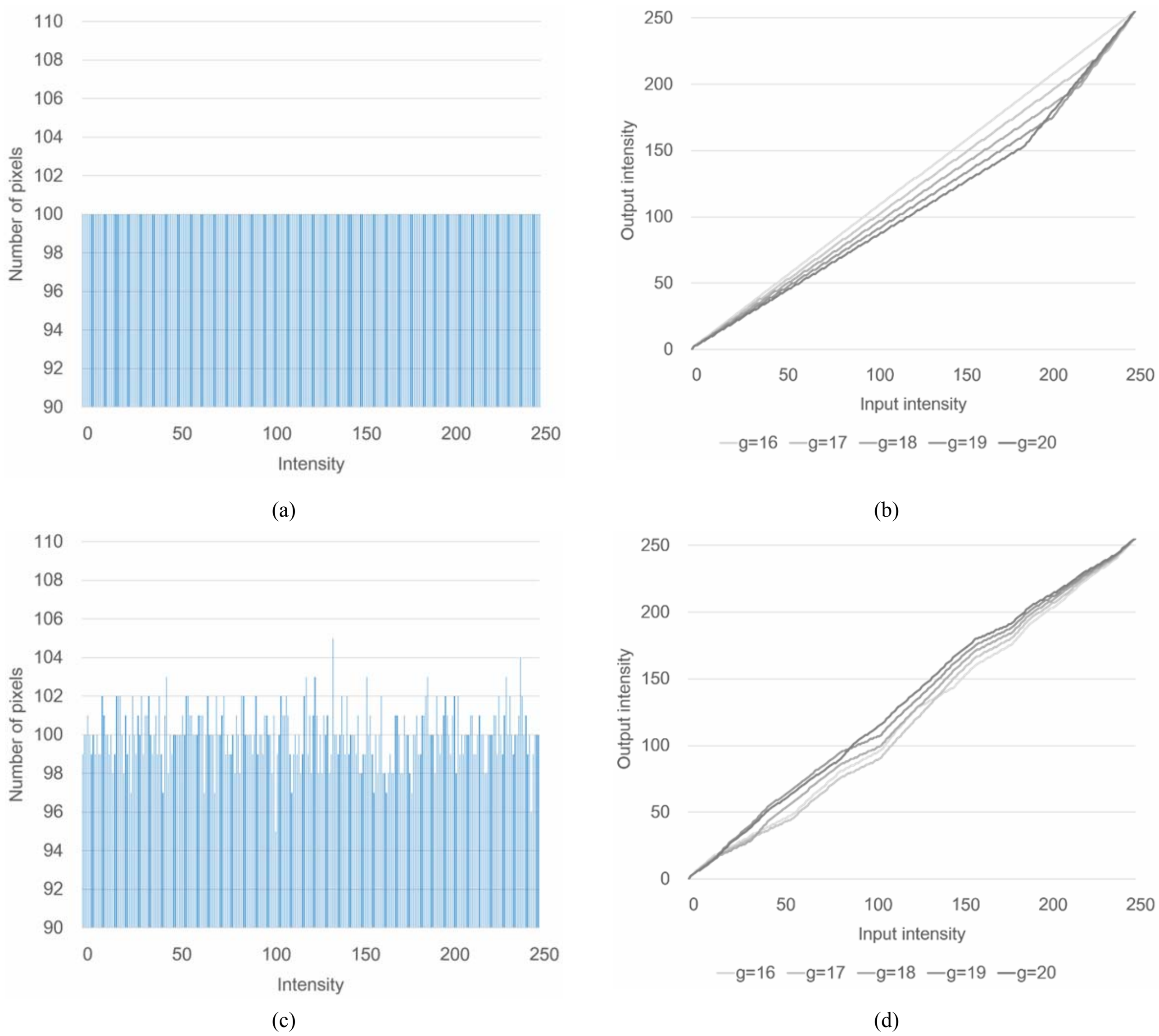


Fig. 1. Transformation functions for each level of the histogram grouping by GLG (a) Uniform histogram, (b) Transformation functions by the grouping of (a), (c) Histogram changed randomly, (d) Transformation functions by the grouping of (c).

means the number of groups. Although (a) and (c) are similar histograms, the results of (b) and (d) show different transformation functions. Because the histogram grouping of GLG is affected by the subtle difference between (a) and (c), it causes a difference in the transformation functions, which is the reason for the flickering effect.

3. Flickering reduction using the modified transformation function

Fig. 2 shows a flowchart of the proposed method. The framework of the proposed method is based on the A-GLG process. The contribution of the proposed method is section shaded. In these sections, the proposed method calculates the difference between a previous transformation function and the current transformation function, and then selects the equation to calculate a modified transformation function using the difference. In previous research, the FGLG was the only flickering effect reduction method applied.

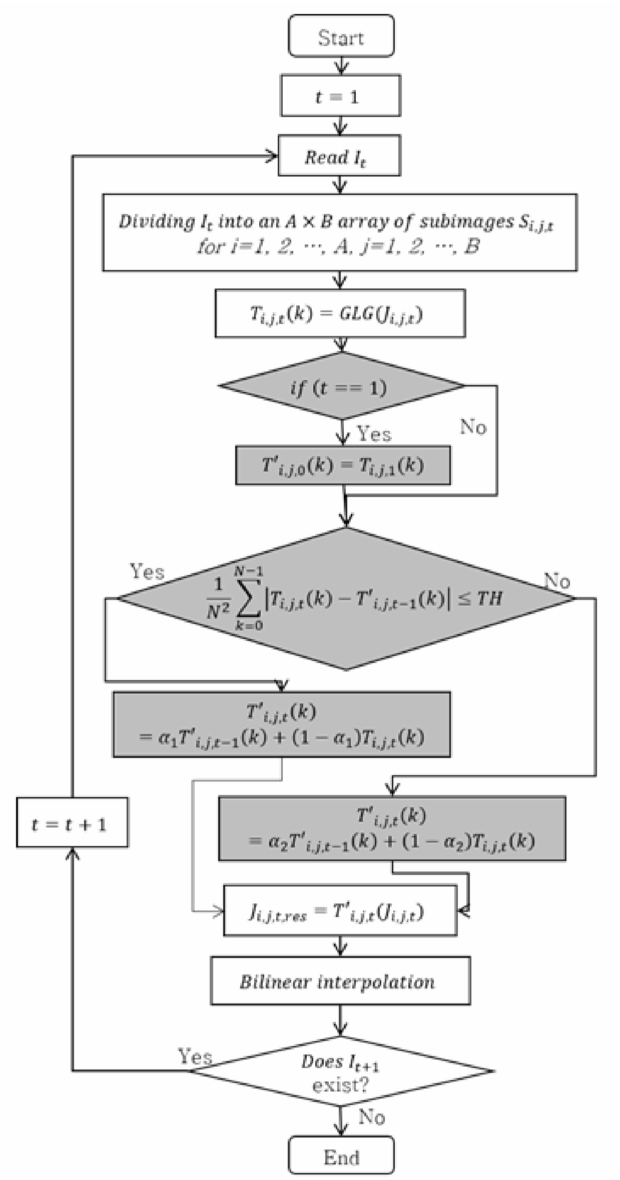


Fig. 2. Flow chart of the proposed method.

To reduce flickering effect, the proposed method uses both transformation functions at a frame $t-1$ and a frame t to calculate the modified transformation function, as in Eq. (1).

$$T'_{i,j,t}(k)=\begin{cases}\alpha_1 T'_{i,j,t-1}(k)+(1-\alpha_1)T_{i,j,t}(k), & \varepsilon \ge TH\\ \alpha_2 T'_{i,j,t-1}(k)+(1-\alpha_2)T_{i,j,t}(k), & otherwise\end{cases} \tag{1}$$

where $T'_{i,j,t}(k)$ is a modified transformation function at a frame t. i and j mean 2D positions of an $A \times B$ array of sub-images for calculation of A-GLG. $T_{i,j,t}$ is a transformation function at i^{th} and j^{th} sub-images of a frame t, k is an input intensity value in the gray scale, and α_1 and α_2 are reference ratios. If α_1 and α_2 are increased, the flickering effect is reduced but the contrast enhancement performance may decrease according the change in the histogram at a frame t. If α_1 and α_2 are 0, however, the proposed method performs like the original A-GLG, and TH is a threshold to check the scene change. ε is a floating value between 0 and 1 and means a difference measurement between $T'_{i,j,t-1}$, and $T'_{i,j,t}$. ε is calculated by Eq. (2)

$$\varepsilon = \frac{1}{M^2}\sum_{k=0}^{M-1}\left|T_{i,j,t}(k) - T'_{i,j,t-1}(k)\right| \tag{2}$$

The proposed method initializes $T'_{i,j,0}(k)$ to $T_{i,j,1}(k)$ and compares ε and TH to select a reference ratio for the calculation of $T'_{i,j,t}(k)$. Over-enhancement can occur at the sub-image if a histogram element of a sub-image has a few bins with a value. The identity transformation can be used to prevent this problem [4].

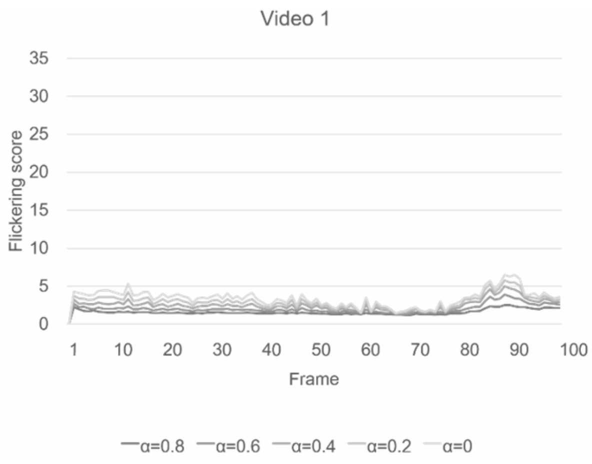
4. Experimental results

The flickering score was used to measure the flickering effect, as expressed in Eq. (3) [5].

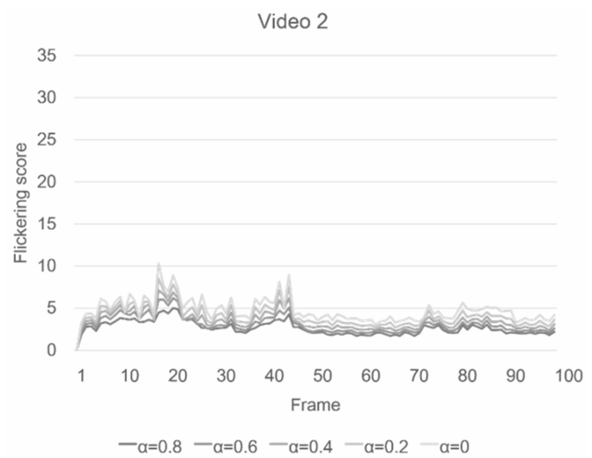
$$Flickering\ \ Score = Avg\frac{\left|\hat{I}_t(n) - \hat{I}_{t-1}(n)\right| + \gamma}{\left|I_t(n) - I_{t-1}(n)\right| + \gamma}$$

$$for\ blocks\ satisfying\left\{I_t(n) - I_{t-1}(n)\right\}^2 < TH\_f \tag{3}$$

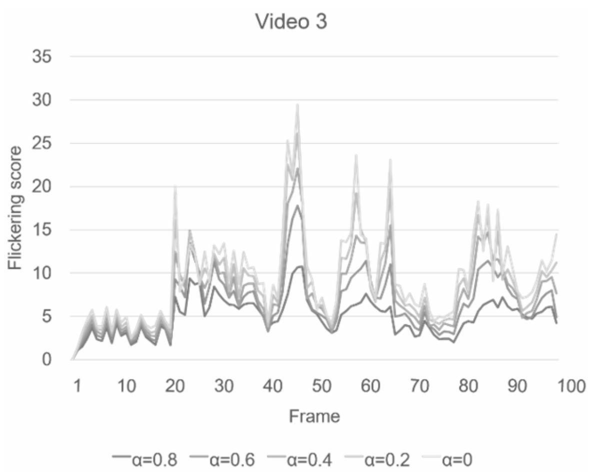
where $I_t(n)$ is the n^{th} block at an original frame t, $\hat{I}_t(n)$ is the n^{th} block at a contrast enhanced frame t, each block 4×4 in size, TH_f is a threshold to select a block used to calculate the flickering score, and γ is a floating number to prevent an excessive increase in the



(a)



(b)



(c)

Fig. 3. Flickering scores of experimental videos.

flickering score. The flickering score 1 at a frame t means that a frame t has no flickering effect. If the flickering effect is increased, the flickering score also increases. The proposed method uses 10 for TH_f and 1 for γ.

Three videos were used to compare the flickering effect reduction. All videos consisted of 100 frames for an experiment. Video 1 is a gray level video. Videos 2 and 3 are the infrared videos. Video 3 is a diversified video. Therefore, this video has a significant flickering effect. Fig. 3 shows the flickering scores at each reference ratio

separately. In this experiment, a scene change was not considered. Hence, α of Fig. 3 means α_1 of Eq. (1). Through Fig. 3, the flickering score increases with decreasing α and vice versa. On the other hand, a lower α for the flickering effect reduction may impede the contrast enhancement performance because a lower α decreases the weight of a histogram change at a current frame.

Table 1. Results of the flickering score.

	Flickering score					
	Video1		Video2		Video3	
α	Mean	SD	Mean	SD	Mean	SD
0	3.4	1.1	4.7	1.4	9.6	5.4
0.2	2.9	1.0	4.1	1.3	8.6	4.8
0.4	2.5	0.8	3.5	1.2	7.7	4.0
0.6	2.0	0.6	3.1	1.0	6.5	3.4
0.8	1.6	0.4	2.7	0.8	4.9	2.1

Table 1 lists the result of the flickering score. The means and standard deviations of the flickering score are inversely proportion to α. This means that an increase in α is dependent on the reduction of the flickering effect. In the experiment, when α is 0.8, the result showed the best performance.

PixDist was used to measure the level of contrast enhancement according to the flickering effect reduction [2]. PixDist means the average distance between the pixels of an enhanced image in the gray scale.

$$D = \frac{1}{N_{pix}\left(N_{pix}-1\right)} \sum_{i=0}^{M-2} \sum_{j=i+1}^{M-1} H(i) H(j)(j-i)$$
$$for\ i,\ j \in [0,\ M-1] \tag{4}$$

where N_{pix} is the total number of pixels, $H(x)$ is the number of pixels at a bin x of a histogram and M is the max value of a gray level. A high PixDist means that the elements of a histogram are spread widely. PixDist is used as a criterion to measure the level of contrast enhancement. This can be used as a contrast enhancement method using the histogram grouping [2].

High PixDist means high contrast; however, an excessively high PixDist reflects the extreme cases. Fig. 4 shows 6 enhanced images and PixDists at each image. Visually, image (f) is the best case for contrast enhancement. Image (b) has the highest PixDist because PixDist means the average distance between the pixels, and the half region of an image (b) consists of black pixels and the other region consists of white pixels. In this case, PixDist has the maximum value but it is over-enhanced. Therefore, a meaningful PixDist range for contrast enhancement is less than 45. In the experiment, PixDist is

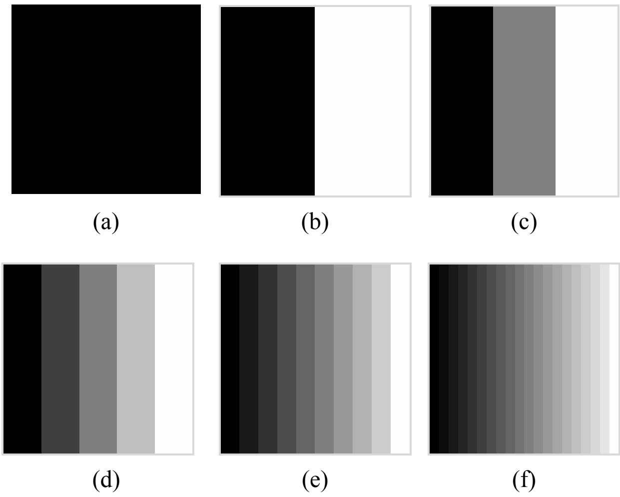


Fig. 4. Example of PixDist (a) PixDist = 0, (b) PixDist = 63.75, (c) PixDist = 56.67 PixDist = 51.04, (e) PixDist = 44.45, (f) PixDist = 43.11, (d).

Table 2. Results of PixDist.

	PixDist					
	Video1		Video2		Video3	
α	Mean	SD	Mean	SD	Mean	SD
0	38.2	0.2	40.0	0.7	30.4	3.1
0.2	38.2	0.2	40.0	0.7	30.5	3.3
0.4	38.2	0.2	40.0	0.7	30.5	3.6
0.6	38.2	0.2	40.2	0.7	30.8	4.3
0.8	38.0	0.3	40.2	0.7	30.8	5.8

over 45 when α is 1. In this case, the enhanced frame is over-enhanced.

Fig. 5 shows the PixDists of the experimental videos. α of Fig. 5 means α_1 or α_2 of Eq. (1). When α is 0, the result is the same as A-GLG. In videos 1 and 2, PixDist is quite stable. In video 3, however, the variability of PixDist is affected by α because video 3 is a low contrast video with the movement of a screen. In Table 2, the means and standard deviations of PixDist in videos 1 and 2 are almost unchanged. The standard deviations of PixDist in video 3, however, increase with increasing α. The means of PixDist of the videos are slightly different. This means that α is independent of the quality of contrast enhancement.

The Tenengrad criterion, which is the most well-known benchmark image sharpness measure, was used to evaluate the flickering effect reduction [7]. The Tenengrad criterion is based on gradient magnitude maximization, as expressed in Eq. (5).

$$S(x, y) = \sqrt{\left(i_x * I(x, y)\right)^2 + \left(i_y * I(x, y)\right)^2} \qquad (5)$$

where $S(\cdot)$ is a sobel operator, I is an input image, i_x and i_y are the convolution kernels of a sobel operator. The Tenengrad criterion (TEN) is calculated as follows.

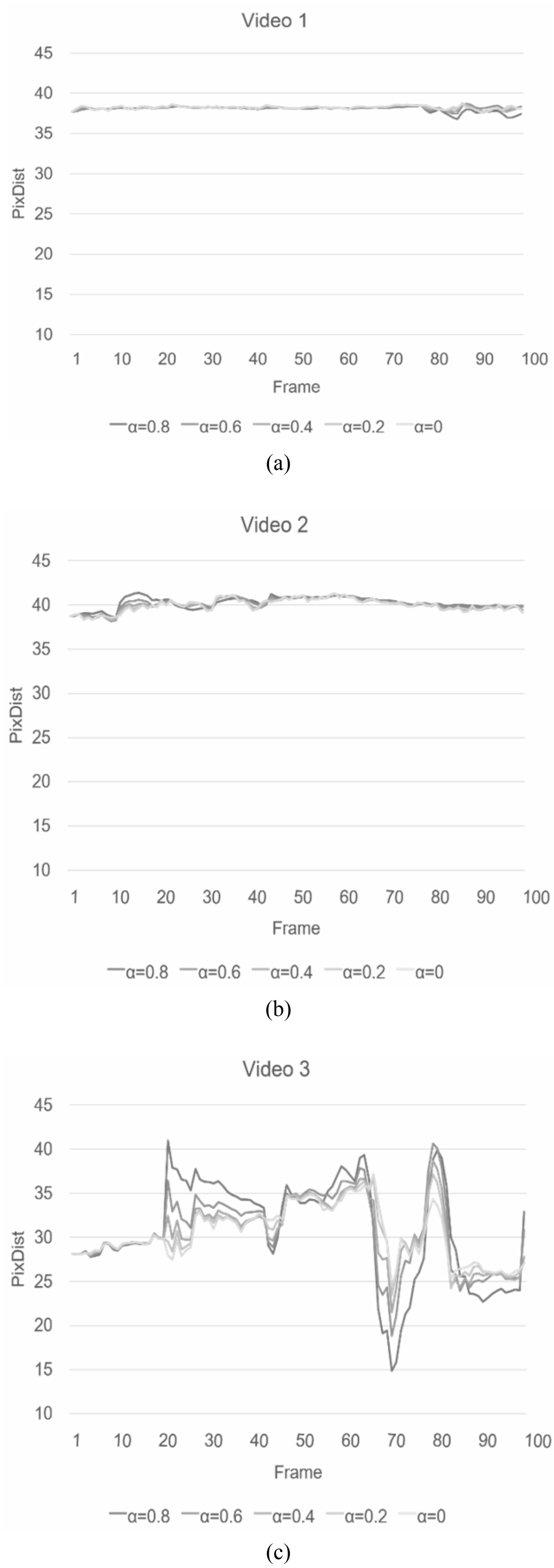


Fig. 5. PixDist of experimental videos.

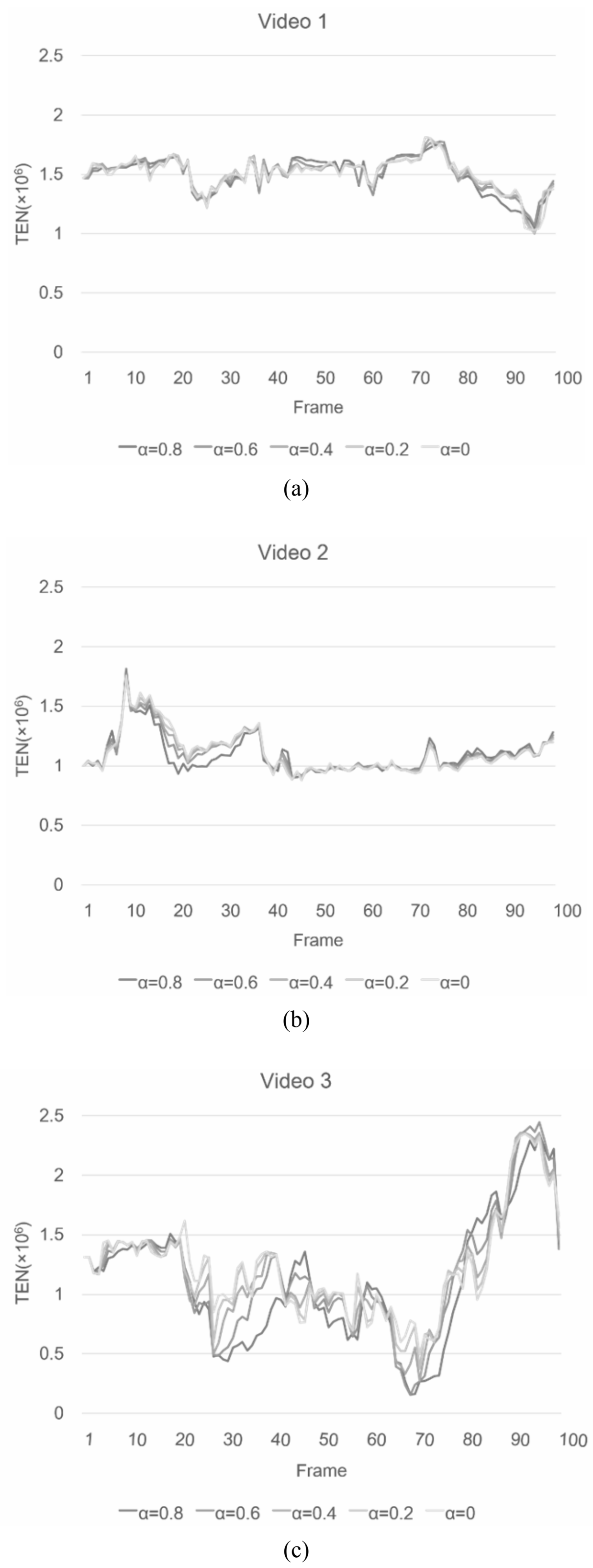


Fig. 6. TEN of experimental videos.

Table 3. Results of the Tenengrad criterion.

	TEN($\times 10^5$)					
	Video1		Video2		Video3	
α	Mean	SD	Mean	SD	Mean	SD
0	15.0	1.5	11.0	1.7	12.0	4.2
0.2	15.0	1.4	11.0	1.7	12.0	4.3
0.4	15.0	1.4	11.0	1.6	12.0	4.6
0.6	15.0	1.4	11.0	1.6	12.0	5.1
0.8	15.0	1.6	11.0	1.6	11.0	5.3

$$TEN = \sum_{x}\sum_{y} S(x, y)^2, \quad \text{for } S(x, y) > T \tag{6}$$

where T is a threshold and used to decide the high frequency of an input image. In the experiment, $\max S(x, y) \times 0.75$ was used for T. A higher TEN means the good quality of an input image.

Fig. 6 shows the TEN of the experimental videos. They have similar trends according to the results in Fig. 5. In video 1 and 2, Table 3 lists the results of TEN. The results show similar means and standard deviations despite the increase in α. In Table 3, the means are relatively constant. This means that the increase in α is independent of the image quality.

Fig. 7 gives an example of the flickering effect. This method was compared with original A-GLG from the 10th frame to the 11th frame. In Figs. 7(c), (f) and (i) are difference images, which were multiplied by 10 for scaling. (c) is the difference image by an original image (a) and (b). (f) is the difference image by A-GLG and (i) is the difference image using the proposed method. Enhanced images, (f) and (i), show a larger difference than the result of (c). On the other hand, the result of the proposed method showed the smaller difference than the result of A-GLG relatively. This means that the proposed method reduces the flickering effect more than A-GLG.

5. Conclusion

This paper proposed a method to reduce the flickering effect caused by A-GLG during video contrast enhancement. The modified transformation function was proposed by previous research, but the method was extended for A-GLG. To reduce the flickering effect, the modified transformation functions were applied to each transformation function of GLG in the A-GLG process. The flickering effect reduction with increasing α was verified by the flickering score. The contrast remained, even though α was increased by PixDist and TEN measures.

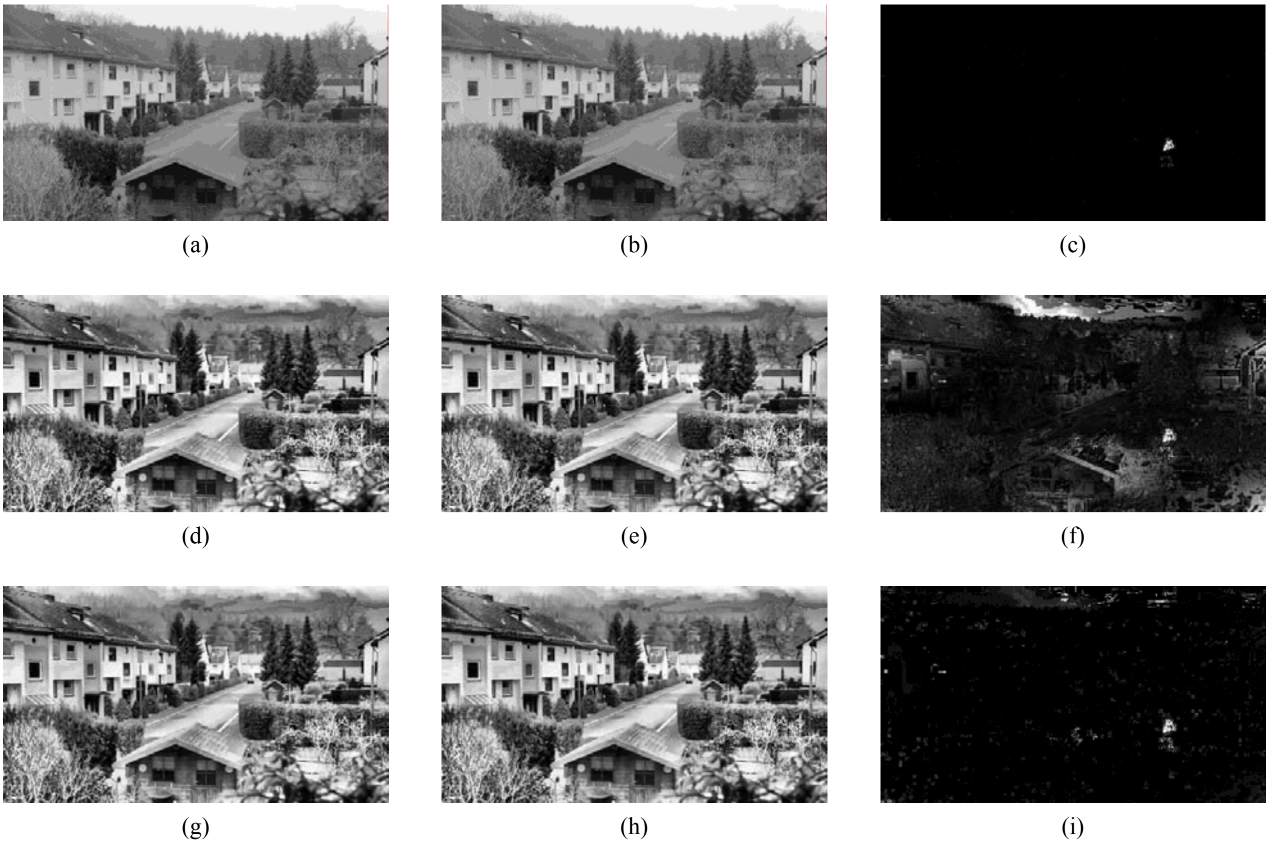


Fig. 7. Example of the flickering effect (a) Original image of the 10th frame, (b) Original image of the 11th frame, (c) Difference image between (a) and (b), (d) Result of A-GLG at the 10th frame, (e) Result of A-GLG at the 11th frame, (f) Difference image between (d) and (e), (g) Result of the proposed method at the 10th frame, (h) Result of the proposed method at the 11th frame, (i) Difference image between the 10th and the 11th frame by the proposed method.

Acknowledgement

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 2012002464).

References

[1] T. Arici, S. Dikbas and Y. Altunbasak, "A histogram modification framework and its application for image contrast enhancement," *IEEE Trans. on Image Processing*, vol. 18, no. 9, pp.1921-1935, Sep., 2009. Article (CrossRef Link)

[2] Z. Y. Chen, B. R. Abidi, D. L. Page and M. A. Abidi, "Gray-level grouping (GLG): an automatic method for optimized image contrast Enhancement-part I: the basic method," *IEEE Trans. on Image Processing*, vol. 15, no. 8, pp. 2290-2302, Aug., 2006. Article (CrossRef Link)

[3] Z. Y. Chen, B. R. Abidi, D. L. Page and M. A. Abidi, "Gray-level grouping (GLG): an automatic method for optimized image contrast enhancement-part II: the variations," *IEEE Trans. on Image Processing*, vol. 15, no. 8, pp. 2303-2314, Aug., 2006. Article (CrossRef Link)

[4] H. S. Yang, J. W. Park and Y. S. Moon "Reducing Excessive Contrast Enhancement by A-GLG," *The Institute of Electronics and Information Engineers Fall Conference*, pp. 483-486, Nov., 2014.

[5] H. S. Yang, J. W. Park and Y. S. Moon "Flickering Artifact Reduction of FGLG in a Video," *Korea Signal Processing Conference*, vol. 27, no. 1, Sep. 2014.

[6] J. Y. Yang, J. B. Park and B. W. Jeon, "Flickering effect reduction for H.264/AVC intra frames," *Proc. of SPIE - the International Society for Optical Engineering*, vol. 6391, Oct., 2006. Article (CrossRef Link)

[7] A. Buerkle, F. Schmoeckel, M. Kiefer, B. P. Amavasai, F. Caparrelli, A. N. Selvan, and J. R. Travis, "Vision-based closed-loop control of mobile microrobots for micro handling tasks," *Proc. SPIE*, vol. 4568, Microrobotics and Microassembly III, pp. 187–198, 2001. Article (CrossRef Link)

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