Adaptive Contrast Ratio Enhancement Algorithm for mobile LCD

Seung-rok Shin[1], Hyun-ha Hwangr[2] ,Byung-sung Bae[3] ,Sung-ho Kimr[4]

[1]Image Lab Corp., Room 304, Center for Business Incubation, Hanyang University, 1271, Sa-Dong, Sangrok-Gu , Ansan-City, Kyunggi-Do, Korea

Tel: 82-31-400-3865 , Fax: 82-31-400-3866, E-mail: daniel@imagelab.co.kr

[2]Image Lab Corp., Room 304, Center for Business Incubation, Hanyang University, 1271, Sa-Dong, Sangrok-Gu , Ansan-City, Kyunggi-Do, Korea

Tel: 82-31-400-3865 , Fax: 82-31-400-3866, E-mail: winston@imagelab.co.kr

[3]School of Display Engineering, Hoseo University, Asan-City, Chungcheongnam-Do, Korea

E-mail: bsbae3@hanmail.net

[4]LG Innotek. Co. Ltd, R&D Center 5F, 1271, Sa-Dong, Sangrok-Gu , Ansan-City, Kyunggi-Do, Korea

E-mail: shkimq@lginnotek.com

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Abstract

We have developed the adaptive contrast ratio enhancement algorithm for mobile LCD. This algorithm aims at effective contrast ratio enhancement with minimizing degeneration of color and white balance. It also is very simple to fit mobile LCD system.

1. Introduction

The small mobile display was mainly for still images. Camera phones, mobile games and DMB(Digital Multimedia Broadcasting) have been very popular nowadays ,and the image quality of mobile display requires similar level of TV's. So image enhancement has got more interesting in mobile displays.

This algorithm is for contrast ratio enhancement with minimizing color deterioration and white balance shift. And it has been developed to be very simple for applying to mobile LCD system. The histogram equalization method, histogram stretching method and gamma curve control method are very effective for C/R (contrast ratio, after this C/R means contrast ratio) enhancement but they sometimes evoke color shift or over-C/R enhancement.

We have analyzed many kinds of picture and studied the histogram characteristics of them. Finally we have made DB (data base) about the histogram characteristics of various pictures. According to this DB, we can decide whether C/R enhancement do or not about each picture and choose the level of C/R enhancement. This idea (so called, 'expert system' for gray histogram of each input image) is the key point of this paper.

2. Experimental

We extracted very simple but powerful algorithm from our expert system. Especially several coefficients of the following step4 and step 5 are decided through our DB (expert system) about gray histogram of pictures.

Our algorithm has 5 steps as follows:

Step 1: Histogram generation of the input image (This histogram has 32 steps.)

Step 2: Searching five maximum frequency values, gray of each max frequency and six minimum frequency values, gray of each min frequency.

Step 3: Comparison of five maximum frequencies and six minimum frequencies.

Step 4: Decision of C/R enhancement execution considering the result of step 3.

$$\begin{aligned} CRE\_OK &<= yes\_cre, \quad when \\ &\min\_freqy\_valx > \max\_freq\_val/coeff. \\ &<= no\_cre, \quad else \end{aligned}$$

Step 5: In what is called “the Ends-in Search”,

$$Out\,\mathrm{Im}\,g[x][y] = Low\_level, \quad when \quad In\,\mathrm{Im}\,g[x][y] \le Low$$

$$= \frac{In\,\mathrm{Im}\,g[x][y] - Low}{High - Low} \times (High\_level - Low\_level), \quad when \quad Low < In\,\mathrm{Im}\,g[x][y] \le High$$

$$= Hig\_level, \quad when \quad In\,\mathrm{Im}\,g[x][y] > High$$

Decision of ‘High’, ‘Low’, ‘High_level’ and ‘Low_level’. Here we consider two maximum frequencies, gray values of each max frequency and three minimum frequencies, gray values of each min frequency.(sub_step1) And One maximum frequency value and the sum of sequential frequencies are compared to generate ‘High’, ‘Low’, ‘High_level’ and ‘Low_level’ value.(sub_step2)

The C/R enhancement of each input image do or not by step 3 and step 4. The input image with the specific emphasized grays should not usually be enhanced because C/R enhancement induces color deterioration in this case. The coefficient in step 4 is decided through step 3. It has a tendency to increase as the difference of max frequency and min frequency decreases.

‘OutImg’ in step 5 means new image’s data through our algorithm. If no C/R enhancement is decided, the output image will be equal to its input image.

Our algorithm has a characteristic that C/R enhancement do effectively according to the histogram of each input image. This means minimization of expression distortion and maximization of power of expression.

3. Results and discussion

Figure 1, 2 and 3 show the results that our algorithm was applied at several images. We could execute contrast ratio enhancement effectively through our algorithm.

Figure 1(a) and 1(b) are the case of no C/R enhancement. The histogram of figure 1 shows that the specific gray is emphasized. If C/R enhancement was done in this case, color distortion would happen.

Our algorithm decides C/R enhancement or not according to characteristic of input image histogram like figure 1 case.

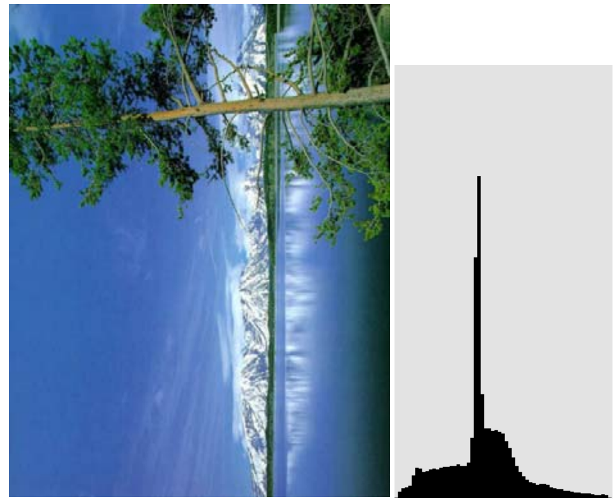

Fig. 1(a). Input image and its histogram (before processing)

(2 line spacing)

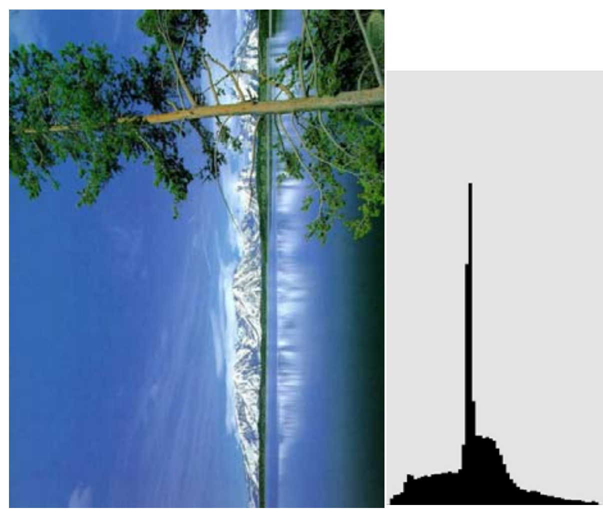

Fig. 1(b). Output image and its histogram (after processing)

Figure 2 is another result. In this case, several grays emphasized more weakly than figure 1. So our system came to conclusion that it was right C/R enhancement does and executed C/R enhancement to figure 2(a) resulting to figure 2(b). We found out that the area of grays in figure 2(b) spreads out more and figure 2 (b) looks more vivid and brighter than figure 2 (a).

Figure 3 is the other result. We know that most of grays except of black (gray level equal to zero) in figure 3 (a) are distributed evenly. In this case, more severe C/R enhancement can be allowed and should be done, because it has little effect if C/R enhancement was done similar level like figure 2.

Fig. 2(a). Input image and its histogram (before processing)

Fig. 2(b). Output image and its histogram (after processing)

Fig. 3(a). Input image and its histogram (before processing)

Fig. 3(b). Output image and its histogram (after processing)

Of cause, We could find out that the area of grays in figure 3(b) spreads out more and figure 3(b) looks more vivid and brighter than figure 3 (a).

4. Summary

Our algorithm is aimed at contrast ratio enhancement. Compared with conventional methods (for example, adaptive gamma or histogram stretch, et al), our algorithm minimizes color degradation or white balance. Our algorithm's key point is that contrast ratio enhancement is executed to input images selectively and properly. Though we started studying from a large scale expert system about histogram characteristic of images, we extracted simple equations from that. So we simulated this algorithm easily by using Visual C.

Our method is very simple, so we are convinced that it can be merged to LCD driver IC or realized as a very cheap separate IC.

5. References

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