S 6-5. Adaptive Gray-level Method Based on Block-based Motion Information for Enhancing Image Quality in PDP-TV

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Abstract: Reducing DFC is quite needed for image quality enhancement under the ADS driving scheme, while keeping a good gray scale rendition. Proposed system can considerably improve the picture quality by using adaptive gray-levels according to the block-based motion information in PDP-TV.

Key Words: PDP, Gray Scale Rendition, Dynamic False Contour.

1 Introduction

Recent development of PDP has remarkably improved the image quality in the area of brightness and contrast, showing the best potential among the large flat panel display (FPD) devices. However there are still various issues to be overcome before PDPs can widely replace CRTs [1]. It is one of the issues under the address display separate (ADS) driving scheme to reduce dynamic false contour (DFC), while keeping a good gray scale rendition (GSR) [2]. The DFC which is an artifact that gray-levels are perceived brighter or darker than the original values when watching a moving image sequence on PDP is one of the culprits to deteriorate the image quality of PDPs. It is caused by the gray-level expression technique of PDPs and the tendency of human eyes of tracking the moving objects [3,4].

There have already been various attempts to reduce DFC. One of them is to divide the subfield having the large weight of subfield [5]. However, this method has a problem of decreasing the available maximum luminance of PDP caused by decreasing the percentage of the sustain period in a TV field by increasing the number of subfields with fixed addressing time. Another approach is to estimate the motion of objects and then compensate the false contour by reassigning subfield data [6]. However, the compensation may be incorrect if eyes do not follow the motion objects exactly and the change of subfield weight position has a defect of generating another noise such as flicker. Recently studied gravity-centered code (GCC) method expresses an image using a limited number of gray-levels to reduce DFC [7]. It is quite powerful for DFC reduction in a moving area but it deteriorates quality of GSR and produces worm artifacts in a static image.

In this paper, we propose the adaptive gray-level method based on the block-based motion information for reducing DFC and improving GSR. The proposed method classifies input images into three types according to the estimated motion information of blocks. Then, different gray-level systems are applied to input images according to the image type.

2 Dynamic False Contour

Currently, one TV field (16.67ms) of commercial PDP is divided into 8~12 subfields. PDPs express an image by selectively combining subfield weight. With this type of subfield driving scheme, neighboring gray-levels are sometimes expressed by very different types of codewords. Two gray-levels which have similar luminance levels can have

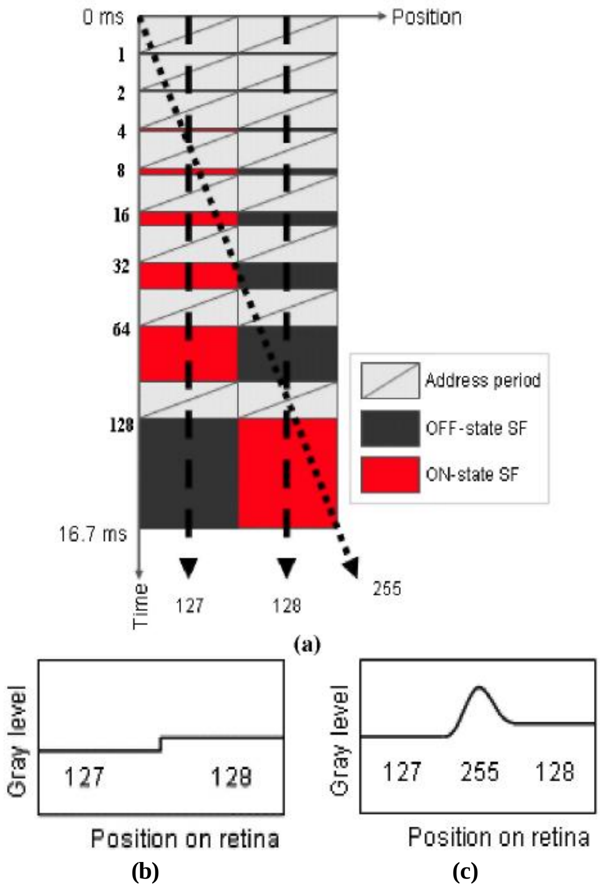

Figure 1 (a) Mechanism of dynamic false contour. In case of (b) static image and (c) moving image about perception between gray-levels of 127 and 128.

quite different codewords. This is the main reason that causes DFC in PDPs. Figure 1(a) shows the mechanism of generating DFC. In this Figure, the codewords of adjacent pixels are [01111111] and [10000000]. When no motion is present, the viewer will integrate each subfield along the 127 and 128 and resultantly perceive the correct luminance. When there is movement in a scene, the human eye will perceive the light of the subfield along the trajectory 255. Consequently, the subfields belonging to the different pixels will be integrated by the human eye. A correct temporal integration without motion leads to a correct luminance as shown in Figure 1(b). However, if the object moves to the right, the brighter line appears between the gray-levels 127 and 128 as shown in Figure 1(c).

3 Adaptive Gray-Level Method

The proposed method divides the input image into blocks and estimates motion information for each block. Then, an input image is classified into three types by using motion information and the adaptive gray-level method is applied to each image according to an image type. Figure 2 shows the flow-diagram of the proposed system.

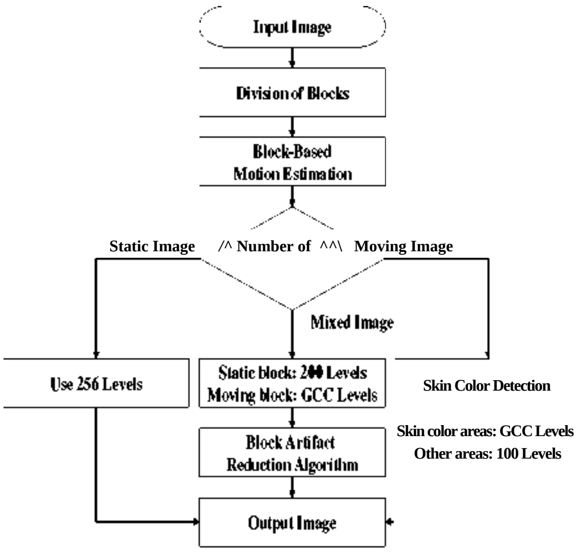

Figure 2 Flow diagram for proposed system.

3.1 Division of Block

The proposed system divides the input image into n Ч m blocks. The number of blocks can be decided by design engineers. If the number of the blocks is too small, the motion information may be too coarse. On the other hand, too many blocks increase the processing time. In this paper, 12Ч12 blocks are chosen through experiments.

3.2 Block Based Motion Estimation

Motion information is estimated for each divided block by using the block-based motion estimation. The full search (FS) algorithm with ±10 searching areas is used in our experiment as a block-based motion estimation algorithm. The FS algorithm checks all the possible displaced candidate blocks within the search area in the previous frame, in order to find the motion vector of the block with the minimum distortion. Apart from the FS algorithm used in this paper, any kind of motion estimation can be used only if it is possible to obtain motion information of each block.

Once the motion vectors of the blocks are determined, each block is classified into a moving block or non-moving block. When the magnitude of a motion vector is bigger than threshold value T_{Motion}, the block is defined as a moving block and MOTION_COUNTER will be increased. Otherwise, the block is defined as a non-moving block. Here, MOTION_COUNTER counts the number of moving blocks.

3.3 Image Classification

Input images are classified into three types (static image, mixed image, and moving image) according to the number of moving blocks. When MOTION_COUNTER is 0, the input image is a static image. When MOTION_COUNTER is bigger than threshold value T_{Type}, the input image is a moving image. Otherwise, the input image is a mixed image. Table I is a criterion for the classification of an image.

Table I Classification of image by moving information.

A class of image	A condition of classification
Static image	MOTION_COUNTER = 0
Mixed image	0 < MOTION_COUNTER ≤ T_{Type}
Moving image	T_{Type} < MOTION_COUNTER

3.4 Image Processing

In the proposed system, the different gray-level system are applied to the input image according to the image type.

A. Static Image

If no moving block exists, the image is defined as a static image. DFC does not need to be considered in this type. Therefore, the proposed system maximizes the image expression by using full 256 gray-levels.

B. Mixed Image

If an image includes both moving blocks and non-moving blocks, the image is defined as a mixed image. A mixed image is an image which has static background and several moving blocks. If 256 levels are used in this type of image, DFC occurs in the area of moving blocks. On the other hand, using a smaller number of levels for DFC reduction deteriorates GSR in the area of non-moving block.

Therefore, both DFC reduction and GSR improvement need to be considered at the same time. In the moving blocks, DFC is reduced by using DFC reduction algorithm, and in the non-moving blocks, GSR is improved by using an approximately 200 number of gray-levels. DFC reduction algorithm in this paper utilizes GCC method for efficient DFC reduction. GCC method expresses an image using a limited number of gray-levels. Error diffusion is used to express the insufficient gray-levels.

When the number of gray-levels is decided for all blocks, there are some cases that neighboring blocks can have very different gray-level system, leading to the artifacts around the boundary area of the blocks. Here, a block artifact reduction algorithm is used to eliminate such artifacts. The block artifact reduction algorithm detects the area where a moving block is adjacent to a non-moving block and then minimizes artifacts between these two blocks by using the 100 intermediate gray-level system.

C. Moving Image

If all the blocks of an image are moving blocks, the image is defined as a moving image. Only DFC reduction is needed in this type. Generally, DFC is often more irritable in a skin color area than in a non-skin color area. Therefore, GCC method is applied to the skin color area for removing DFC and about 100 gray-levels are used for the non-skin color area, which is more tolerant to DFC. After converting RGB to HSV color coordinate, the skin color area can be simply detected by a decision criterion [8].

$$0 \le H \le 50,\ 0.20 \le S \le 0.68,\ 0.35 \le V \le 1.0. \tag{1}$$

4 Experimental Results

To evaluate the performance of the proposed algorithm, a visual test has been performed to evaluate the different gray-level systems. Figure 3 shows the simulation results of a mixed image in which a sphere moves between two static backgrounds of gradation. As shown in Figures 3(b) and (c), the PDP system using 256 gray-levels generates many DFCs in a moving sphere, and the PDP system using only GCC method inevitably introduces much half-toning error in the gradation image. In contrast, as shown in Figure 3(d), the proposed system expresses the gradation image more smoothly and also effectively reduces the DFC which appears inside the moving sphere. Figure 4 shows the simulation result for a moving image in which the whole image moves to right direction. As expected, the proposed system effectively reduces the DFC while keeping a good GSR.

Table II shows the result of human visual evaluation in an actual 42-inch PDP especially built for the experiment. As for each image type, we showed four participants ten processed images, each tested on GCC, 100 gray-levels, 256 gray-levels, and the proposed system. A participant ranked an image with a grade ranging from 4(best) to 1 (worst) according to the picture quality. The average grades for 40 images are shown in Table II. It is found that the proposed method shows relatively the good performance, especially being ranked the highest in mixed images by reducing both DFC and GSR errors.

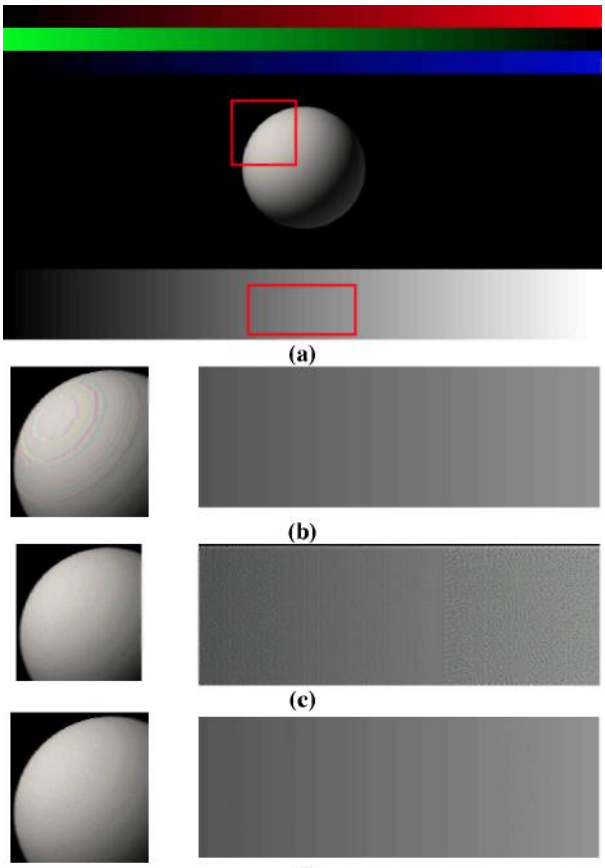

Figure 3 Simulation results of (a) original image for mixed image and two enlarged images in (b) 256 gray-levels system, (c) GCC system, and (d) proposed system. Here, left and right images are part of moving sphere and static gradation, respectively.

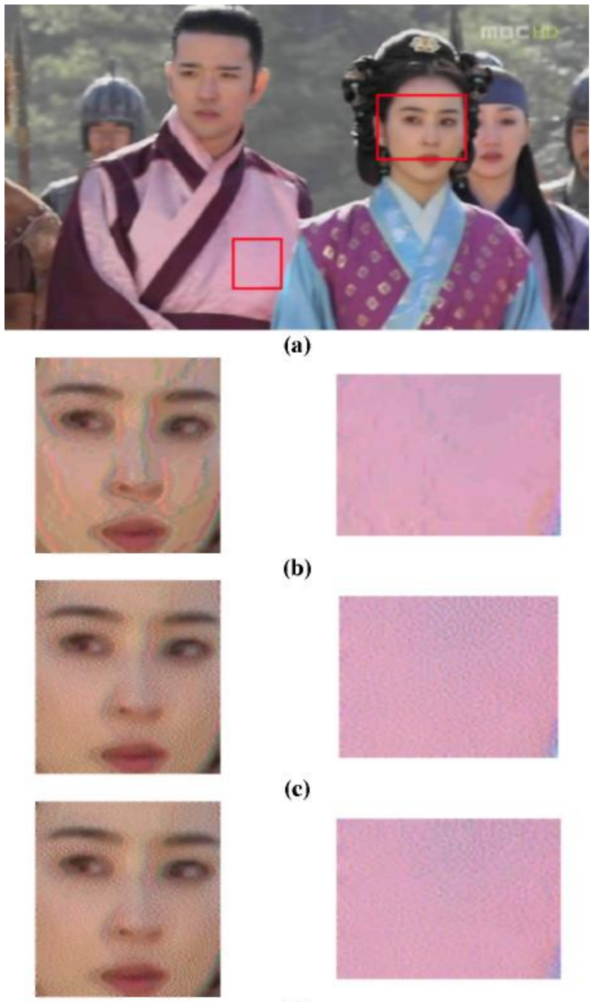

Figure 4 Simulation results of (a) original image for moving image and two enlarged images in (b) 256 gray-levels system, (c) GCC system, and (d) proposed system.

Table Ⅱ Average grades of human, visual evaluation with a grade ranking from 4 (best) to 1 (worst).

A class of image / Systems	Static	Mixed	Moving	Average
33(GCC) system	2.50	3.10	3.30	2.97
100 system	3.08	2.45	2.80	2.78
256 system	3.83	1.18	1.20	2.07
Proposed system	3.83	4.00	3.63	3.82

5 Conclusions

Currently, images are expressed by the limited number of gray-levels for DFC reduction on commercial PDPs. It is good for DFC reduction, but it deteriorates the quality of GSR. In this paper, we propose the adaptive gray-level system for enhancing image quality of PDPs by reducing DFC and improving GSR. This method enhances GSR in the non-moving area and reduces DFC in the moving area. We can obtain a better image quality using the propsed method by dynamically selecting the gray-level system according to the motion information compared with the previous method that uses the static gray-level system, because the proposed method can enhance both the DFC reduction and GSR improvement which are in the relation of trade-off. By various experiments, the proposed system using adaptive gray-levels according to the block-based motion information can considerably improve the picture quality of PDP-TV.

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