Reducing Motion Artifacts of Plasma Display Panel Using Motion Information

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Abstract

Plasma Display Panels(PDPs) suffer from motion artifacts because of subfield driving method. In this paper, a modified motion compensation method is proposed. We apply the optimized mapping table to the higher subfield group and the fill-up method to the lower subfield group to generate optimum mapping patterns. This method does not concentrate 'on' mappings on higher subfields. Therefore it can possibly become a more robust motion compensation.

1. Introduction

Plasma Display Panels(PDPs) have become increasingly popular in the large flat display market. However, due to the subfield driving method, PDPs suffer from motion artifacts such as 'false contour noise' and 'motion blur'. When the moving images are displayed on a PDP, false contours are visible at smooth gray scale areas (false contour noise) and edges of images are blurred (motion blur).

Various methods have been proposed to reduce these motion artifacts such as changing the subfield distribution [1], using equalizing pulses [2], omitting the gray levels which introduce false contour noise (CLEAR method [3], GCC method [4]) and so on. These methods reduce the false contour noise but increase the motion blur and result in other deteriorations.

Using motion information reduces motion artifacts with all gray-levels and less subfields. M. A. Klompenhower and G. Haan [5] proposed the fill-up method that decides the mapping of sub-fields to make the intensity perceived by eyes along the motion trajectory similar to the original intensity.

In this paper, we propose a modified motion compensation method to overcome the limitations of previous methods. This method is built on the earlier fill-up method to arrive at the best possible motion compensation. The difference between the fill-up method and the proposed method is that, when deciding the mapping of subfields, the optimized mapping table is used to the higher subfield group and the fill-up method to the lower subfield group. It generates the optimum mapping patterns.

This paper is organized as follows: In section 2, we discuss the mathematical modeling of human eyes' perceiving the lights from a PDP. In section 3, we analyze the fill-up method and propose the modified method to prevent the disturbances of motion artifacts effectively. In section 4, we show some results to compare the proposed method to others, and draw conclusions.

2. PDP Eye Tracking Model

The process of perceiving the lights emitted by a PDP is shown in figure 1. It illustrates the viewer tracking the moving pixel and integrating the subfields along the motion trajectory, i.e. subfields belonging to different pixels. The upper part of figure 1 indicates the location of pixel and eyes to the corresponding subfields on the x-y plane of panel and the lower part shows how human eyes integrate light pulses of subfields.

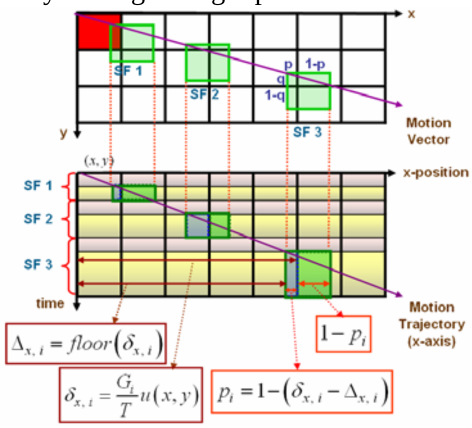


Fig. 1. PDP eye tracking model.

Each subfield is divided into 2 parts - reset/address period and sustain period because it is generally assumed that the length of reset/address period are always the same and the lights are assumed to be emitted only during sustain period. $\boldsymbol{\delta}_i(\delta_{x,i}, \delta_{y,i})$ is the displacement of eyes to i-th subfield, G_i is the gravity center of light of i-th subfield, T is the field period, u is x-directional element of motion vector $\mathbf{v}(u, v)$ and $\boldsymbol{\Delta}_i(\Delta_{x,i}, \Delta_{y,i})$ is the greatest integer value, which dose not exceed $\boldsymbol{\delta}_i(\delta_{x,i}, \delta_{y,i})$.

The intensity perceived by eyes along the motion trajectory can be derived as where

$$\begin{aligned} I(x,y) = \sum_{i=1}^{N} W_i \times \Big[& p_i \cdot q_i \cdot SFmap_i\left(x+\Delta_{x,i}, y+\Delta_{y,i}\right) \\ & +(1-p_i)\cdot q_i \cdot SFmap_i\left(x+\Delta_{x,i}+1, y+\Delta_{y,i}\right) \\ & + p_i \cdot (1-q_i)\cdot SFmap_i\left(x+\Delta_{x,i}, y+\Delta_{y,i}+1\right) \\ & +(1-p_i)\cdot(1-q_i)\cdot SFmap_i\left(x+\Delta_{x,i}+1, y+\Delta_{y,i}+1\right)\Big] \end{aligned} \quad (1)$$

$SFmap_i(x, y)$ denotes the state of subfield at (x, y) (0 or 1), N is the number of subfields and W_i is the weight of i-th subfield.

3. Motion Compensation

3.1. Deciding The Mapping Of Subfields

Motion artifacts can be compensated by deciding the mapping of subfields to make the intensity perceived by eyes along the motion trajectory close to the original intensity. To do so, it should be supposed that the location of eyes to i-th subfield is fixed at (x, y) because we can only decide the mapping of subfield at the integer position. The position of eyes to i-th subfield corresponding to the pixel at (x, y) is $(x+\delta_{x,i}, y+\delta_{y,i})$

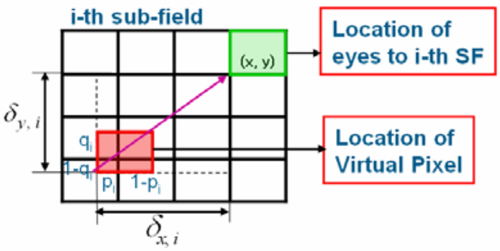


Fig. 2. The virtual pixel corresponding to the i-th subfield at (x, y).

in figure 1. If the location of eyes to i-th subfield is (x, y), the position of the corresponding pixel should be $(x-\delta_{x,i}, y-\delta_{y,i})$. We call the pixel at this non-integer position the 'virtual pixel' corresponding to the i-th subfield at (x, y) which is shown in figure 2.

The intensity of virtual pixel can be derived from the bilinear interpolation of 4 existing neighbor pixels in the current picture as follows:

$$\begin{aligned} I_{virtual,i} &= I(x-\delta_{x,i}, y-\delta_{y,i}) \\ &= p_i \cdot q_i \cdot I\left(x-\Delta_{x,i}, y-\Delta_{y,i}\right) \\ &\quad +(1-p_i)\cdot q_i \cdot I\left(x-\Delta_{x,i}+1, y-\Delta_{y,i}\right) \\ &\quad + p_i \cdot (1-q_i)\cdot I\left(x-\Delta_{x,i}, y-\Delta_{y,i}+1\right) \\ &\quad +(1-p_i)\cdot(1-q_i)\cdot I\left(x-\Delta_{x,i}+1, y-\Delta_{y,i}+1\right) \end{aligned} \quad (2)$$

From this value, the mapping of subfields at (x, y) can be decided. There can be several methods to decide the mapping of subfields and the performance of compensation depends on each method. We analyze the fill-up method and propose the modified motion compensation method built on this fill-up method in the following sections.

3.2. The Fill-Up Method

This method decides the mapping of subfields in the order of subfield weight to make the intensity perceived by eyes along the motion trajectory close to the original intensity. In this method, the sum of the intensity over the last completed subfields ($I_{accumulate}$) and the weight of current i-th subfield (W_i) are kept from exceeding the original intensity ($I_{virtual,i}$). This process is described in (3) and $I_{accumulate}$ can be calculated from (1).

$$\begin{aligned} & if\ (I_{accumulate}(x-\delta_{x,i}, y-\delta_{y,i}) + W_i \le I_{virtual,i}) \\ & then\ SFmap_i(x, y) = 1 \\ & else\ SFmap_i(x, y) = 0 \end{aligned} \quad (3)$$

This method minimizes the difference between the intensity perceived by eyes along the motion trajectory and the original intensity so that the motion artifacts can be reduced effectively. The computer simulation result of this method is shown in figure 3. However, it has a serious problem which prevents it from being applied to practical PDP driving.

Generally, the number of subfields is more than 8, thus there can be several mapping patterns for a gray level. The optimum mapping pattern which introduces

(a) Non- compensation (b) The fill-up method

Fig. 3. The virtual pixel corresponding to the i-th subfield at (x, y).

the least motion artifacts has the minimum gravity center of light [4] among the mapping patterns. The gravity centers of light for all 256 gray levels are shown in figure 4 and the points in different colors indicate the optimum mapping patterns.

The serious problem mentioned above is that the fill-up method cannot generate optimum mapping patterns. Since this method 'fills up' the subfields in the order of weight, 'on' mappings are concentrated on the higher subfields to increase the gravity center of light of gray levels. This phenomenon results in the increment of interference between subfields and severe noises can be introduced by motion estimation error and movements of eyes. To minimize these noises, the optimum mapping patterns should be generated.

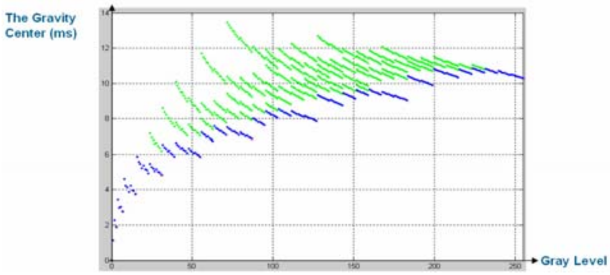


Fig. 4. The gravity centers of all 256 gray levels. 10 subfields (1-2-4-8-16-24-32-40-56-72).

3.3. Proposed Method

In general, subfields can be divided into 2 groups - the lower subfield group which has the weights of power of 2 and the higher subfield group which has ordinary weights. There is only one pattern for a gray level in the lower subfield group and if the mapping of higher subfield group is decided, that of lower subfield group can be optimized by the fill-up method. Hence, we apply the optimum mapping table to the higher subfield group and the fill-up method to the lower subfield group to generate optimum mapping patterns. The subfields generated by the fill-up method and the proposed method are shown in figure 5. Although both methods generate subfields to make the intensity perceived by eyes along the motion trajectory close to the original intensity, the proposed method does not concentrate 'on' mappings on higher subfields. Thus, the proposed method reduces the motion artifacts and minimizes the noises introduced by motion estimation error and movements of eyes.

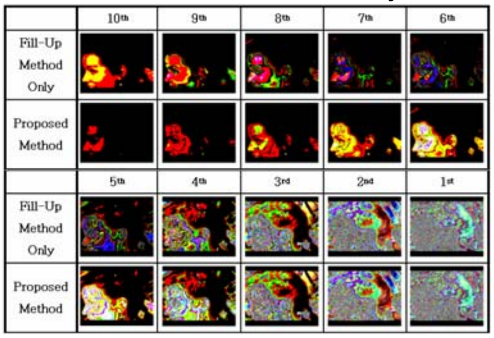


Fig. 5. Subfields generated by the fill-up method and proposed method. 10 subfields (1-2-4-8-16-24-32-40-56-72).

For an effective compensation by the fill-up method, there should be at least 5 subfields in the lower subfield group. If there are less than 5 subfields in the lower subfield group, errors introduced by the higher subfield group are not compensated perfectly and noises can occur. Examples of proposed method are shown in figure

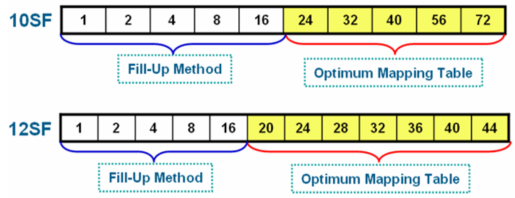


Fig. 6. The gravity centers of all 256 gray levels. 10 subfields (1-2-4-8-16-24-32-40-56-72).

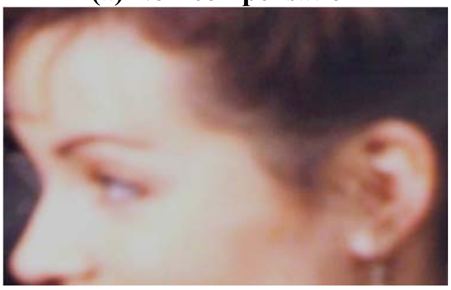
6. The optimum mapping table is applied to the

higher subfield group (10 subfields: 24-32-40-56-72, 12 subfields: 20-24-28-32-36-40-44) and the fill-up method to the lower subfield group (both: 1-2-4-8-16) to decide the mapping of subfields.

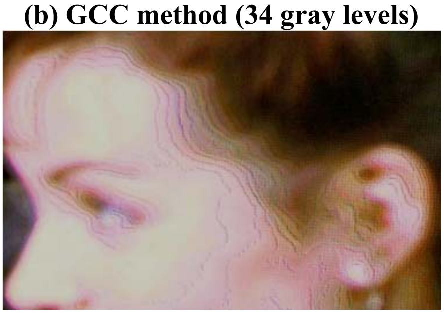
4. Experimental Results

The result images on a practical PDP are shown in figure 7. These images are taken by a digital camera with the shutter speed fixed at 1/60 second. We use 10 subfields (1-2-4-8- 16-24-32-40-56-72) in our experiment. The GCC method only reduces false contour noise and introduces additive deteriorations such as halftone noise and flicker. The fill-up method increases the interference between subfields to critically degrade the image quality unlike the computer simulation result(figure 3). The proposed method reduces motion artifacts and minimizes the noises introduced by motion estimation error and movements of eyes.

(a) Non-compensation



(b) GCC method (34 gray levels)



(c) The fill-up method

(d) Proposed method

Fig. 7. Result images on PDP.

5. Conclusion

In this paper, we have proposed a modified motion compensation method for PDP. We divided the subfields into 2 groups; the higher subfield group and the lower subfield group. We then applied different methods for the mapping of subfields to each group (the higher subfield group: the optimum mapping table, the lower subfield group: the fill up method) to generate the optimum mapping patterns. Thus, this method can reduce motion artifacts and minimize additive noises. With an accurate motion estimator, it effectively improves the moving picture quality on PDP.

6. References

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