Generalized Motion Artifacts Index Usable for Various Patterns of Video Images

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Abstract
An integrated pattern profile distortion is newly proposed to analyze various two-dimensional test patterns. The unit is converted to a time to make parameters comparable for various types of displays. In addition, this can be compared with that of extended blur edge width in time scale, which has been reported.

1. Introduction
Motion blur, dynamic false couture and color break are the three major important artifacts of flat panel displays (FPDs) beside existence of many types of motion artifacts. Motion blur has been reduced by several techniques such as overdriving, material/structural improvement of LCDs and an image process engine. As the result, an image quality of various video displays made from LCDs is improved. In this circumstance, an accurate, objective and commonly usable methodology to parameterize the strength of motion artifacts has been requested.

A display quality index of motion blur has been studied. A system to acquire a pursuit image is one of good devices to measure motion blur 1). One of motion blur parameter is a blur edge width (BEW) of moving pattern 2). To make parameters comparable between many types of display, normalized parameter namely blur edge time (BET) 3) or extended blur edge time (EBET) 5) are proposed.

There are several arguments on the blur edge width. One is that the human eye perception of display image is a contrast. Furthermore, in case of impulse type driving on LCDs, the BET versus response time is not a smooth curve and may not be an appropriate perceptive parameter 4). To match with those arguments, we proposed usage of parameter called an edge profile distortion (EPD) and the integrated value (IEPD) may be a perceive parameter of motion blur 5).

In case of TV displays, motion artifacts of video images and blur of letter on a running telop are obvious phenomena. We have tried to measure motion blur index of such video images of 2-dimensional pattern, which will be a type of video picture.

We have continued development of algorithm for motion artifact parameter usable for 2D video image and report advancement in this paper.

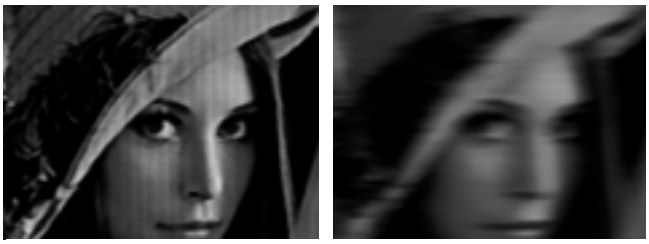

Fig. 1, Still image of stationary picture and a pursuit image of scrolled picture on LCD-TV. Scroll speed is 10 ppf.

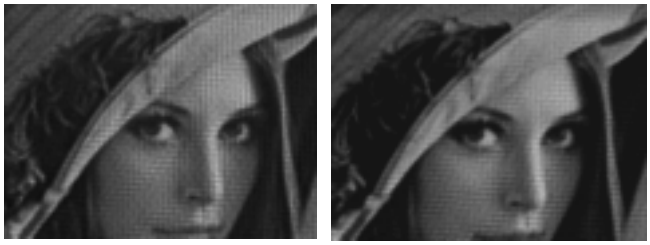

Fig. 2, Still image of stationary picture and a pursuit image of scrolled picture on CRT-Mon. Scroll speed is 10 ppf.

2. Image process
A pursuit image of moving picture displayed on a tested display is taken by a pursuit camera system as described in our previous paper 1). In addition, a still image of stationary picture is taken without pursuing. Figure 1 and 2 show those images of LCD for TV (LCD-TV) and CRT for PC monitor (CRT-Mon). Horizontal cross-sections of images at right side eye position are shown in figure 3 and are blurred at the scroll speed of 10 pixel per frame (ppf).

Two kinds of images of 1: scrolled picture and 2: stationary picture are processed by FFT filters as shown in figure 4. Several kinds of filters are tried to eliminate vibration on a profile caused by a LCD pixel structure. The filters are a function of filtering

point and Q value such as used commonly for signal processing. A frequency space data obtained by FFT is multiplied by a filter function, which is an absolute value instead of complex number. Notch filter with high frequency cut is best for this purpose combining with a low pass filter. As a result of filtering, vibration on a profile is eliminated such as shown in figure 3.

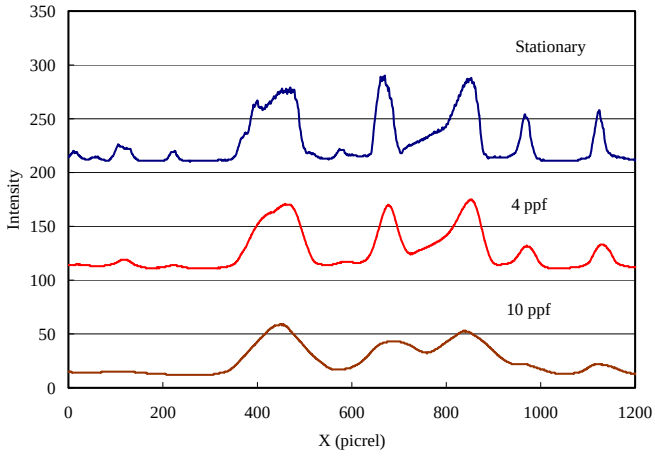

Fig. 3. Cross sectional profile of still and pursuit image at different scroll speeds. Sample is LCD-TV.

A simulated blurred image (C in fig. 4) is created by simulation from a non-blurred still image (B) and is compared with blurred image (A). Image C is a function of T_{EBET}, which is a parameter having a time unit and is same meaning as EBET: extended blurred edge time, 6). Simulated blurred image is an average of horizontally sifted images of B. A shift step is one pixel on image. Total number of shift N is given by equation 1).

$$N = \frac{T_{EBET}}{T_{FP}} M_{CCD/LCD} R_{LCD/VIDEO} S \quad \ldots 1)$$

Where, S: scroll speed of image of video content in ppf, $M_{CCD/LCD}$: magnify factor of image (=CCD pixel/LCD pixel), $R_{LCD/VIDEO}$: ratio of horizontal pixel of LCD against that of video image and T_{FP} is a period of one frame.

In case that a gray scale transition curve is not a straight line, a weight function of response curve will be applied on the averaging.

3. Analysis

Two methods are tried to obtain a motion blur strength index from a pursuit picture.

3.1 Distortion analysis of blurred image

Integrated pattern profile distortion of sample image is a sum of absolute intensity difference from reference as shown in equation 2).

$$D = \frac{\sum \left| I_{Sample}(x,y) - I_{\text{Reference}}(x,y) \right|}{\sum 1} \quad \ldots 2)$$

where I is an image intensity as a function of image pixel coordinate x and y. One of image is noted ”Sample” and the other is “Reference”. The summation is conducted at a certain region of a image (30x50 LCD pixels in case analysis of this paper). The scale of intensity is signal intensity or normalized luminance. Lightness scale may be taken in some case. Signal intensity will be normalized by two values, maximum intensity at highest level and dark level. To conduct the normalization, two block of highest and lowest level should be placed at a top or bottom region of test image in addition with dark level measurement.

Before conducting summation, two images need to be aligned with each other. A correlation of two

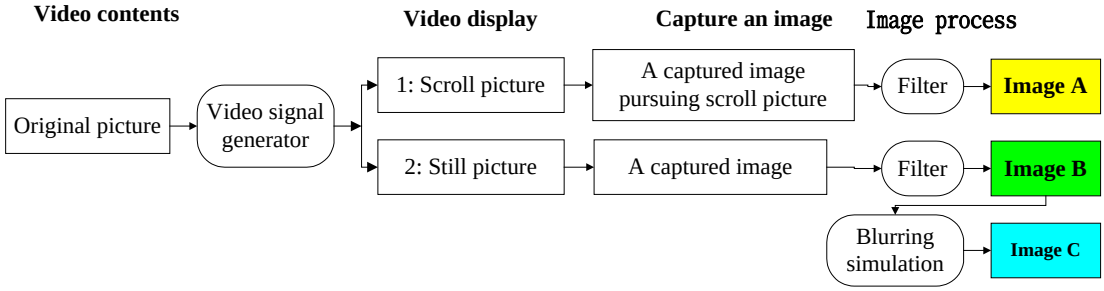

Fig. 4. Image process of a pursuit A, still B and simulated C images.

images is given by an equation 3). Get a maximum correlation by shifting alignment position.

Correlation=

$$\sum 1 \Big/ \sum (I_{Sample}(x,y) - I_{\text{Reference}}(x,y))^2 \quad \ldots 3)$$

Figure 5 indicates mapping of correlation between a blurred and still images.

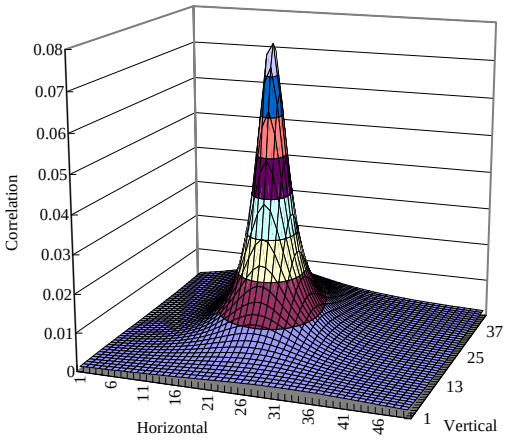

Fig. 5. Two dimensional mapping of correlation between two images.

Integrated profile distortion of pursuit image and simulated image are plotted in figure 6 and 7 in case of LCD-TV and CRT-Mon The simulation are made as assuming that a display is an ideal hold type and extended blurred edge time is one frame period.

Observed distortion is composed from three components as shown by equation 4).

$$D = d_{Move} S + D_{Still} - D_0 \quad \ldots 4)$$

d_{Move} : Coefficient of moving image distortion

S : Scroll speed in pixel per frame

D_{Still} : Still image distortion

D_0 : Distortion caused by image filter

First term is a component being proportional with scroll speed. Still image distortion is an image blur at infinitely small scroll speed. Since the reference image is filtered to eliminate LCD pixel structure, the image creates blur equal with that created by scrolled speed of one ppf. Therefore, an intercept of D value of simulated image at x-axis is one ppf and an intercept at y-axis is $-D_0$.

Blurred pattern time T_B is obtained by using equation 5). This corresponds with a blurred edge time (EBET) obtained from a blurred edge width of two gray block test pattern. However, obtained value is based on a distortion of picture image.

$$T_B = T_{Simulate} \frac{d_{Move}}{d_{Move,Simulate}} \quad \ldots 5)$$

where $T_{Simulate}$ is a frame period, which is used as an assumption of simulation. $d_{Move,Simulate}$ is a coefficient of moving image distortion of simulated image.

In case of CRT-Mon as shown in figure 7, an integrated distortion is independent on scroll speed. How
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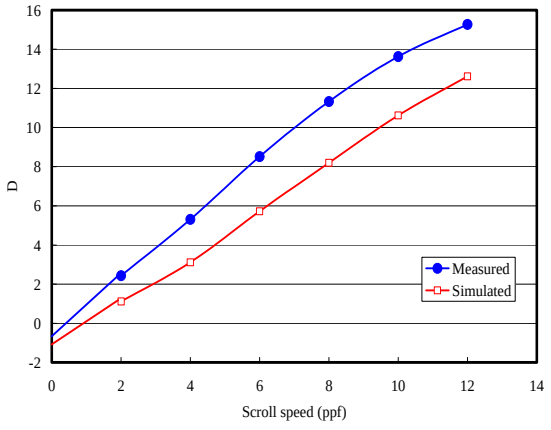

Fig. 6. Integrated distortion of Lena picture on LCD-TV.

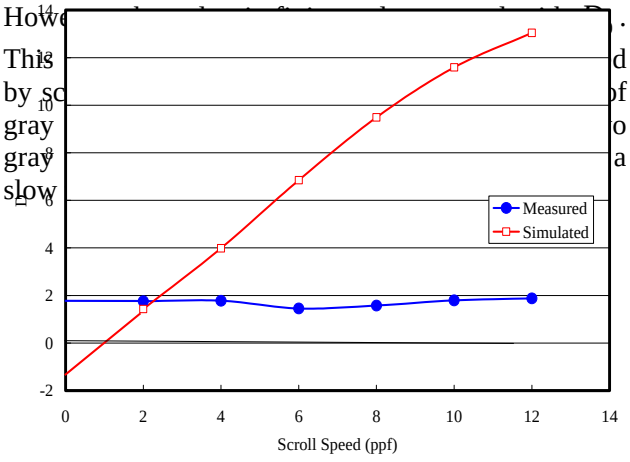

Fig. 7. Integrated profile distortion of Lena picture on CRT-Mon.

3.2 Correlation analysis

Horizontal cross section of simulated images at various $T_{Simulate}$ are shown in figure 8. Correlation between pursuit image and simulated images are plotted as a function of $T_{Simulate}$ as shown figure 9. Blurred pattern time T_B is obtained as $T_{Simulate}$ at maximum correlation. This method is a type of non-linear least square method. Thus obtained T_B has a dependence on scroll speed. The values after correction of still image blur are shown in Table 1.

4. Discussion

Blurred pattern time of moving picture obtained by two methods and extended blurred edge time obtained by moving two gray block pattern are compared as shown in table 1. Three kinds of values are close with each other. Small difference may be caused by difference on gray scale distribution of picture.

5. References

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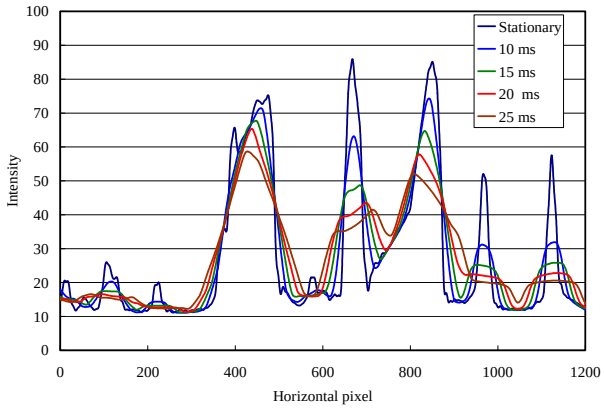

Fig. 8. Cross-section of simulated Lena picture at various $T_{Simulate}$ and of still image. Sample is LCD-TV.

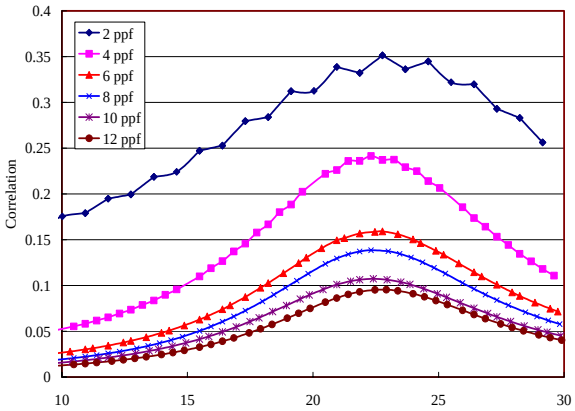

Fig. 9. Correlation as a function of $T_{Simulate}$ measured at various scroll speeds.

	Distortion analysis		Correlation analysis		EBET (ms)
	T_B (ms)	Still image blur (pixel)	T_B (ms)	Still image blur (pixel)	
LCD-TV	20.7	0.5	22.8	-0.1	23.0
LCT-TV(impulse)	6.9	1.3	7.9	0.8	11.0
PDP	10.1	1.1	7.7	0.7	12.5
CRT-Mon*	-0.1	2.2	2.5	0.7	0.2

Table 1. Comparison of moving blurred pattern time and extended blurred edge time. *) EBET is a slope of Blurred Edge Width vs. scroll speed.