# Novel Measurement Method for Evaluating Moving Picture Quality of Display

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## Abstract

*We propose a novel method to measure moving picture quality of display. This method simulates human visual system based on CSF (Contrast Sensitivity Function). And it evaluates moving picture quality of display on the image captured by pursuit camera. The results from this method are correlated with human visual perception test very well.*

## 1. Introduction

Conventional image quality measurement methods and numerical values are not related to human visual system. Especially display resolution is just pixel number and it can't describe well how moving picture in display really looks. Because a moving picture quality is related to characteristic of display driving method and pixel number. Each display to have same pixel number could have different moving picture quality. For this reason, human test is needed in order to evaluate accurate display quality. But it is too inconvenient and subjective and each test has different result.

We developed a new measurement method for evaluating moving picture quality of display. Moving picture quality is related to perceptual image resolution. Resolution is spatial frequency. Perceptual spatial frequency is changed in moving picture owing to characteristic of human visual system. Therefore, we designed the method which is correlated with human visual system. And we set up a measurement system using MPRT-1000 and compared this system with human perception test in order to verify our method. Results from test showed that our method is correlated with human perception very well.

## 2. Proposed Method

We developed an algorithm to evaluate and quantify moving picture quality of display. This numerical value of quality is called '*moving picture resolution*'. For each scroll speed and each pattern image, proposed algorithm evaluates maximum spatial frequency which human can distinguish image contrast. Moving picture resolution is defined as this maximum spatial frequency value. Contrast is defined as below.

$$Contrast = \frac{MAX - MIN}{MAX + MIN} \quad (1)$$

Human eye has different contrast sensitivity for spatial frequency. This theory is defined by contrast sensitivity function (CSF). [1]

$$A(f) = 2.6 \cdot (0.0192 + 0.114 f) \cdot e^{-(0.114 f)^{1.1}} \quad (2)$$

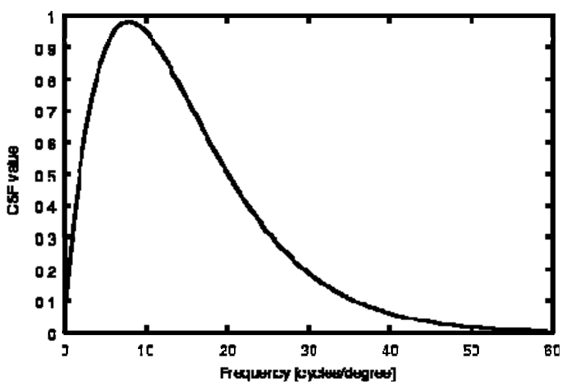


**Fig. 1. Contrast Sensitivity Function (CSF)**

$f$ means frequency(cycles/degree). From this formula we can compute contrast threshold value. (formula 3) Human can not distinguish image contrast

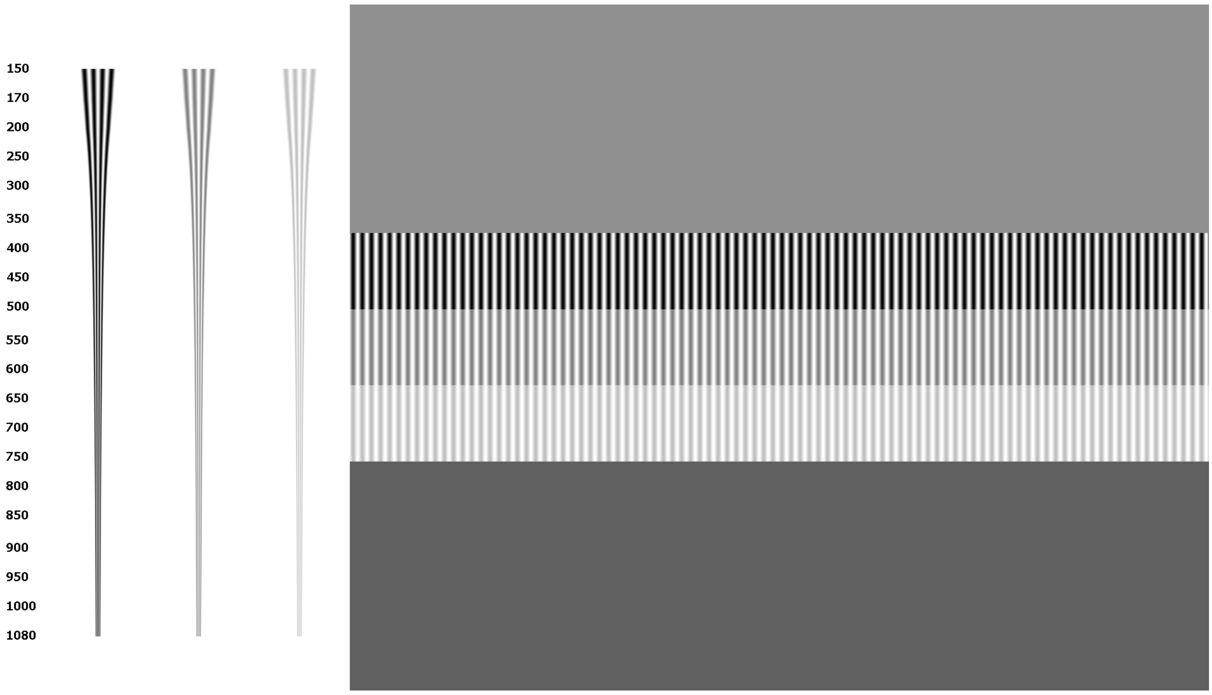


**Fig. 2. Pattern image for human perception test (left part), Pattern image for capture (right side)**

when moving picture contrast is under contrast threshold. $f_{input}$ is spatial frequency of input pattern image. W and H are width and height of display. $3H$ means normal viewing distance. We set 25 to $\alpha$ in formula 3 after human perceptual test.

$$\text{Contrast Threshold}(c_\tau) = \frac{1}{\alpha \cdot A(f)} \quad (3)$$

$$f = f_{input} \cdot \frac{3H \cdot \tan\left(\frac{\pi}{360}\right)}{W} \quad (4)$$

We evaluated moving picture quality using FFT(Fast Fourier Transform) to get accurate results.

## 3. Experimental

In order to verify our proposed method we compared with a measurement system and human visual perception test.

### 3.1 Measurement System

We set up a measurement system for evaluating moving picture quality using MPRT-1000(fig). MPRT-1000 has a pursuit camera. This camera pursues and captures a scrolled image. This capture method is based on human visual system. Human eye pursue a moving object in moving picture instinctively. Therefore, we can get same images as human perception. Proposed measurement method uses these images.

We made several sine wave pattern images for measurement system. Right part of fig 2 is the image for measurement system. Each image has a different spatial frequency and contrast. Fig 3 is one of captured sine wave pattern images.

<u>*Display Setting Rules*</u>

a. Sharpness function off
b. 60p input signal
c. Input pattern image signal to display using pattern generator

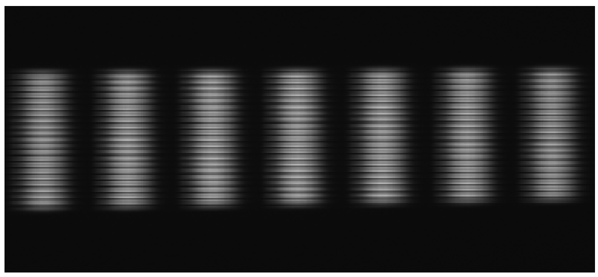

**Fig. 3. Captured sine wave pattern image**

3.2 Human Visual Perception Test

In order to verify our method and system, we performed human visual perception test with 10 observers. We made another sine wave pattern images which is different from images for measurement system. In these images case, each pixel has a different spatial frequency and each image has a different contrast. These images are more convenient for human perception test. (Fig 2. left part) Observers find blurred line at scrolled pattern image. Blurred line means that observers can not distinguish contrast of sine pattern. Left numbers of image are moving picture resolution.

Human perception test is sometimes inaccurate because it is subjective evaluation. For this reason, we made rules to obtain accurate results as below.

*Human Perception Test Rules*

a. Light Condition: 150 lux, 6,500 K
b. Viewing Distance: 3 x display height
c. Do test from low to high scroll speed for observers to adopt scroll speed.
d. Search from low frequency(high part of image) to high frequency(low part of image)
e. Take a rest every half hour to avoid human eye fatigue

3.3 Experimental

We evaluated moving picture quality of PDP, LCD and 120Hz LCD. All of display has Full HD resolution (1920x1080). And 9 kinds of contrast images are used to acquire accurate results. (255-0, 255-128, 255-192, 192-0, 192-96, 192-144, 128-0, 128-64, 128-96) Scroll speed was 2, 4, 6, 8, 10 and 12 pixel per frame (ppf). Moving picture resolution is computed in each case. And we compare the results of proposed measurement system with human visual perception test results.

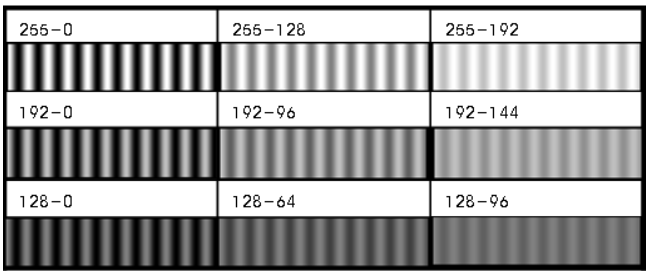


**Fig. 4. Part of sine pattern image**

## 4. Results and discussion

Fig 5 is results from experimental. PDP display has higher moving picture resolution value than LCD's. This is manly caused by hold type driving on LCD. The 120Hz LCD has different result of moving picture quality on different input signal. We guess that it is up to ability of frame rate conversion technique. Fig 6 shows that our method is correlated with human visual perception very well. In that case adjusted $R^2$ value is 0.93.

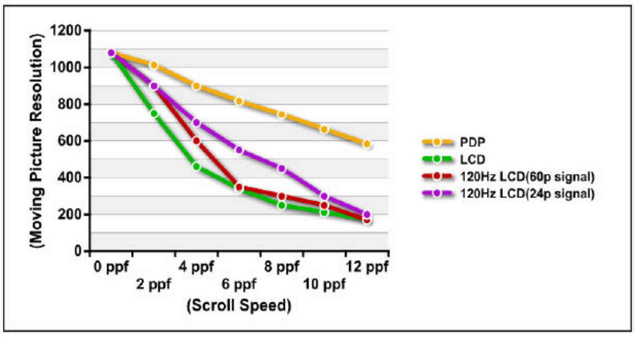


**Fig. 5. Result from experimental**

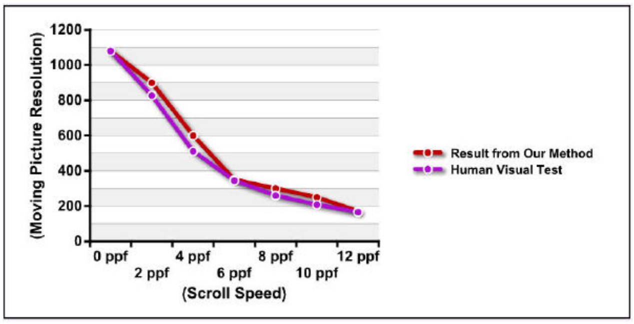


**Fig. 6. Comparison between measurement system and human visual perception test (120Hz LCD, 60p signal)**

## 5. Conclusion

New moving picture quality measurement method was introduced. This method can compute moving picture quality which is similar to human vision. This is more useful value than resolution (pixel number) for evaluating moving picture quality of display. Proposed method shows that displays which have same resolution could have different quality on moving picture. And we verify our method by human visual perception test.

But our method has limitations. The display which has sub-field driving method like PDP has false contour problem. Our method measures this artifact partly. But sometimes it can't measure this artifact exactly. On future works we will improve our method through considerations of some artifacts and colors.

## 6. References

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