High Contrast Image Projection using Electronic Paper Screen -Confirmation of Performance in a Bright Room -

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Abstract

Projected image on a screen is not always vivid enough when it is projected in a bright room where audiences want to read paper documents simultaneously. We have suggested a new projection system which can realize high contrast image projection in a bright room. It is consisted of electronic paper screen, projector and LED room light. The e-paper screen alternates its whole surface white/black with 120Hz. Room lights are controlled with the same frequency of 120 Hz with the opposite phase as that of the e-Paper screen. We have confirmed that our new system has achieved higher contrast than the conventional projection system and also enough readability of paper documents in the room simultaneously. We have thus confirmed that our new system can bring an ideal condition, for audience, which can realize a vivid image projection in a bright room.

1. Introduction

Projected image on a screen is not always vivid enough when it is projected in a bright room. We generally have to choose either vivid image in a dark room or dull image in a bright room.

We have suggested a new projection system which can realize high contrast image projection in a bright room. This paper describes the construction and performance of a prototype of vivid image projection system using an e-paper screen.

2. Principle of operation

Figure 1 shows timing diagram of our new projection system. An e-paper screen switches between black and white states. A projector is operated as usual with no ON/OFF. A room lighting switches between ON and OFF states with the same frequency and the opposite phase with the switching of the screen.

The room lighting turns ON only the screen is black state. That is why we can prevent the obstructive reflection of room lighting from the screen. The frequency should be higher than flicker value for our eyes. Figure 2 illustrates the alternating twin states of our new projection system.

3. Experimental method

Table 1 shows experimental conditions. The construction of our projection system is illustrated in Fig. 3. Figure 4 is a photograph of the experimental system. A pulse generator was used for simultaneous ON/OFF control of the e-paper screen and also the LED room lighting. Figure 5 and Figure 6 shows actual photograph of the two states of our projection system, which correspond to the alternating two states illustrated in Fig. 2 (a), (b) respectively.

The performance of our new projection system was compared with the conventional projection system with and without room lighting. "The conventional system with a continuous room lighting" state was simply simulated by a continuous lighting with a half illuminance that of used in our new system; screen is continuously white state without switching. "Conventional system without room lighting" state was also simulated simply by cutting off the room lighting in our new system.

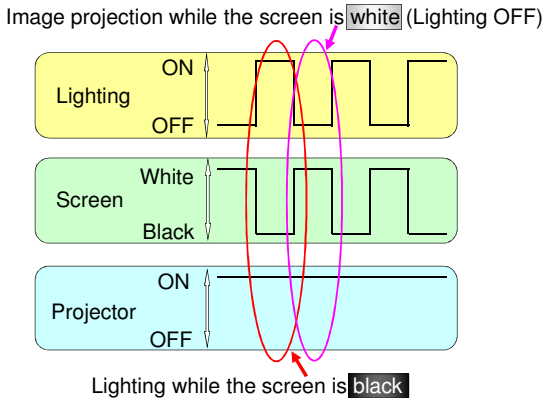

Fig. 1 Principle of our new projection system (Timing diagram).

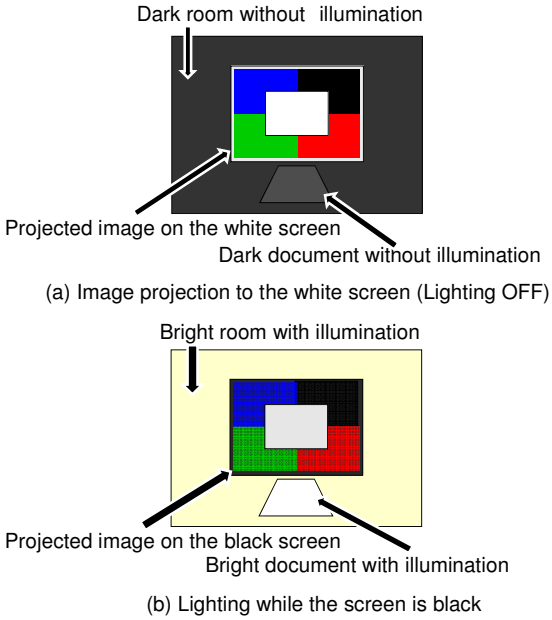

Fig. 2 Alternating two states in our new projection system (Illustration).

Performance of the three states of image projection were evaluated by measuring the luminance of the screen when full white image and when full black image was projected. The mean value of luminance on the screen was calculated by averaging the measured value at 3×3 divided areas of the screen. Image contrast of projected image was calculated as a ratio between mean values of luminance of a white image and a black image.

We carried out relative evaluations between our new system and conventional system with room lighting by collecting subjective answers of 10 subjects for the following items:

1. Vividness of image.
2. Brightness of image.
3. Contrast of image.
4. Flicker of the screen.
5. Flicker of the room lighting.
6. Brightness of the desktop.
7. Readability of the document sample on the desktop.
8. General impression.

Subjects were requested to answer the relative superiority / inferiority by choosing their answer from (-2, -1, 0, +1, +2). "+2" means extreme superiority of the new system. "-2" means extreme inferiority of the new system.

Table 1 Experimental condition.

Items		Conditions
Electronic Paper		QR-LPD(R) (Bridgestone)
Screen size		326 × 435 mm
Operating frequency		120 Hz
Test room		Soundproof chamber 315 × 211 × 224 (cm)
Illuminance	New system	460 lux
	Conventional system with continuous room lighting	460 lux
	Conventional system without room lighting	0 lux
Projector		LCD projector: EMP-1810 (EPSON), 3500 lm
Subjects		10 students
Projected image for subjective evaluation		"Geographer" by Vermeer

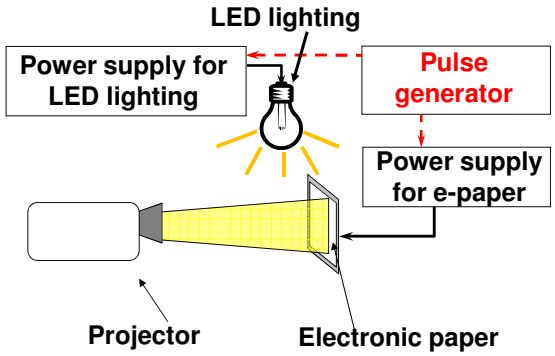

Fig. 3 Illustration of the experimental system.

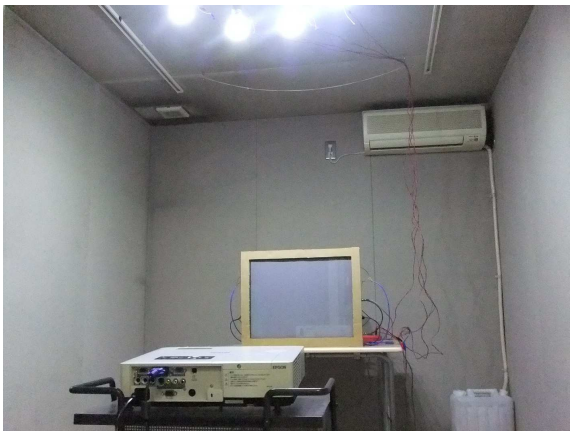

Fig. 4 Experimental system.

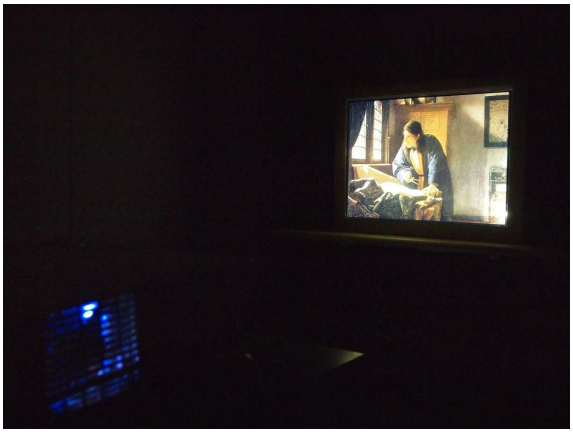

Fig. 5 Image projection to the white screen (Lighting OFF).

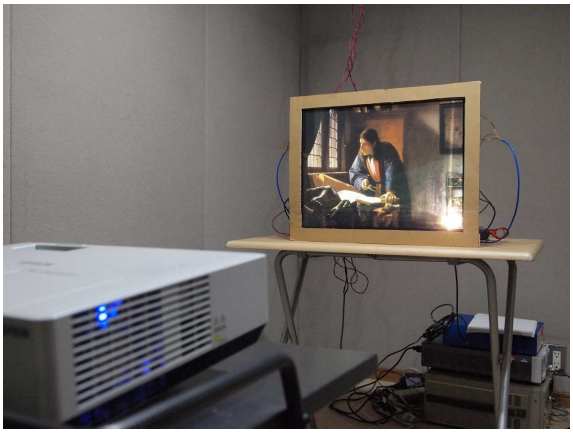

Fig. 6 Lighting at the timing when the screen is black.

4. Results

Table 2 and Fig. 9 show measured performances of the three conditions. We can find the following results in these measured results:

Image contrast: (Conventional system with lighting) < (New system) ≪ (Conventional system without lighting), luminance of the paper on the desktop: (Conventional system without lighting) < (New system) ≒ (Conventional system with lighting).

Photographs of the projected image for subjective evaluation for the two conditions of projection with alternating continuous lighting were shown in Fig. 10, 11. Table 3 shows results of the subjective evaluation; relative superiority of the score (-2 to +2) by the new system is shown in this table.

Subjective evaluation scores indicate rather notable superiority of the new system in "Vividness of image", "Contrast of image", and "General impression". Our anxiety of supposing inferior score for flicker of screen was proved to be needless worries as a result.

Consequently, we have confirmed that our new projection system could realize more vivid image projection than conventional system in a bright room where paper documents were readable.

Fig. 10 Conventional system with lighting.

Table 2 Results by the 3 systems.

	Luminance (cd/m^2)			Contrast ratio
	Black area	White area	Paper on the desktop	
Conventional [with room lighting]	15.2	478.0	61.8	31
New system	6.5	325.1	62.4	50
Conventional [without lighting]	1.1	433.3	3.0	394

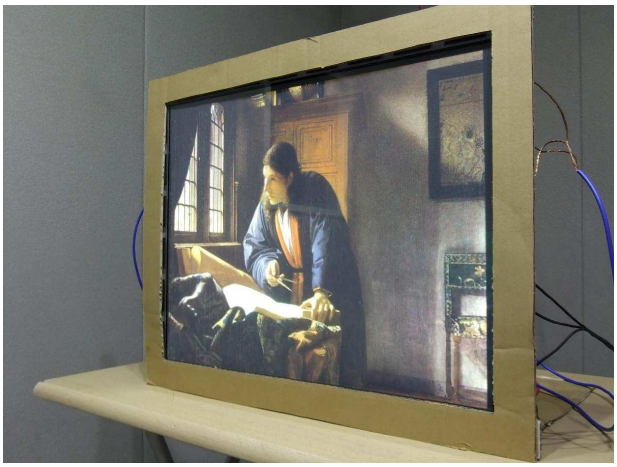

Fig. 11 New system.

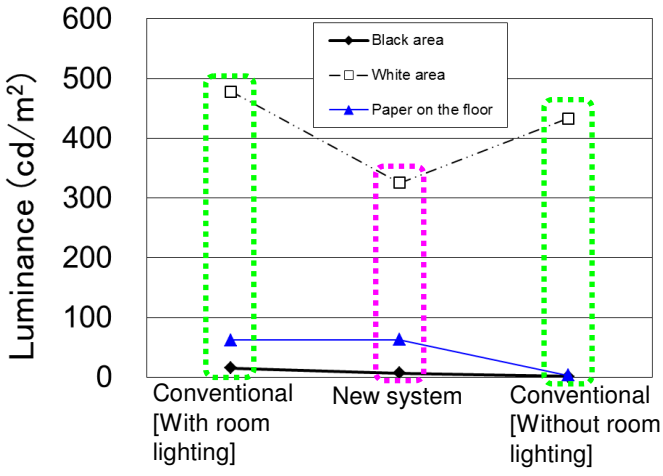

Fig. 9 Comparison of the 3 systems.

Fig. 12 Conventional system without lighting.

Table 3 Results of subjective evaluation: relative score for the new system compared with the conventional system with continuous lighting.

Evaluation items	Relative score
Vividness of image.	0.6
Brightness of image.	0.0
Contrast of image.	0.6
Flicker of the screen.	0.2
Flicker of the room lighting.	-0.2
Brightness of the desktop.	-0.1
Readability of the document sample on the desktop.	0.2
General impression.	0.5

5. Conclusion

1. We have prototyped a novel projection system which consists of an alternating e-Paper screen, an alternating LED room lighting, and conventional projector in order to achieve a vivid image projection in a bright room.
2. Measured results have shown that more vivid and clear image projection than that of in conventional system is achieved by our new system. The improved vividness and contrast have also been confirmed by subjective evaluation results.

Acknowledgement

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Reference

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Author Biography

Tsukasa Kinjo was born in 1987. He received his B.E. degree in 2010 from Tokai University. He is expected to receive his M.E. degree from the graduate school of Tokai University in 2012. He is now engaged in a study of Image Projection using Electronic Paper.