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Prototyping of Practical e-Tile and Evaluations of Joint Gap Area Effect

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ABSTRACT

"e-Tile" is introduced as a novel concept for large area displays. A typical e-Tile configuration, in which 100 pixels are mounted on a 100 mm square board, was designed and practically prototyped. The effect of the joint gap area of the tiled display on the image quality was evaluated by subjective evaluation of the simulated tile images.

1 Introduction

The first great application of e-Paper has been e-Books. Now we are eagerly waiting for the next key application of e-Paper[1]. A very promising candidate application is large area displays.

Arrayed panels of LEDs or LCDs are currently being used for large area displays, i.e. display areas with over 100 inch diagonal widths. A fatal weak point of these large area displays is their huge power consumption.

The applications of these large area displays can be categorized into two groups: 1) Video displays like TV, and 2) Still image displays for mainly characters and pictures like paper posters. Nonvolatile display methods are obviously favored for still image displays because they consume power only during rewriting operations. e-Paper technologies, typically electrophoretic displays, are promising for the large area still image displays; the reflective nature of e-Paper brings the key advantage of lower power consumption[2]. However, the current size of electrophoretic display products is not enough for large displays by one panel.

The unique concept "e-Tile", which typically consists of 100 pixels in a 100 mm x100 mm square board, has been suggested3), 4) by Electronic Paper Consortium of JBMIA (Japan Business Machine and Information System Industries Association). e-Tile can cover any size of area by arraying necessary number of tiles.

Figure 1 illustrate the display walls constructed using e-Tiles. The merit of e-Tile is its extensibility to areas of any size; only one size of e-Tile need be produced. We have designed, built, and tested an e-tile prototype. Assuming a relatively large pixel size on the electronic tile, the relationship between the viewing distance and the impression of image quality was studied by calculations and subjective evaluations.

2 Practical Prototyping of e-Tile

We have built a practical prototype of e-Tile. Fig. 2 shows a 10 cm square e-Tile in which 1 cm pixels are arranged in 10 x 10 = 100 pixels. The tile weight is only 42 g and the thickness is 5.5 mm. Tile surface is covered with acrylic resin to ensure mechanical surface strength and moisture resistance. Each pixel on the tile is directly connected to a driver circuit on the tile and is individually driven.

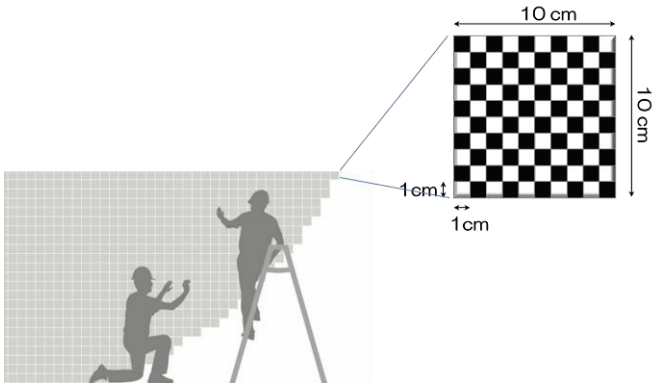


Fig. 1 Construction of a large display wall by e-Tiles

In this second prototyping, we prepared a base panel (50 cm square: Fig. 3) for mounting 25 tiles. It is assumed that a factory will ship base panels with 25 tiles already mounted on it. The practicality is improved by the simple installation method of mounting this 50 cm square base panel on the wall at the site. Fig. 4 shows a photo of a base panel with 25 tiles mounted on it. Fig. 5 shows a typical example of displayed image on e-Tiles. An rectangle area of 50 x 100 cm (50 × 100 = 5,000 pixels) is covered by using two base panels. Table 1 shows the main specifications of e-Tile and base panel.

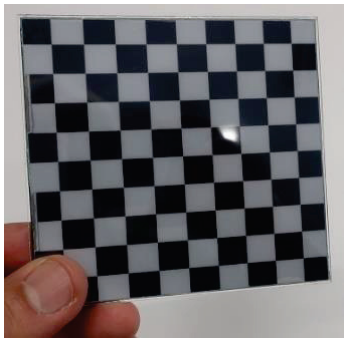


Fig. 2 Practical prototype of e-Tile.

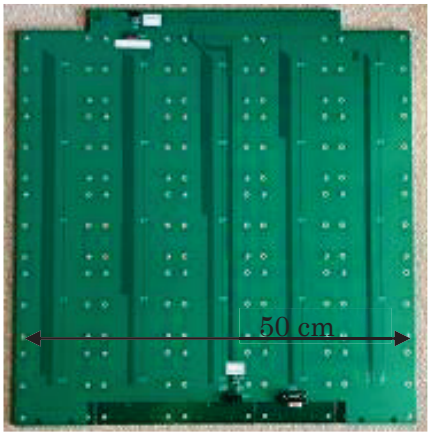


Fig. 3 Base panel for arraying 25 pieces of e-Tiles.

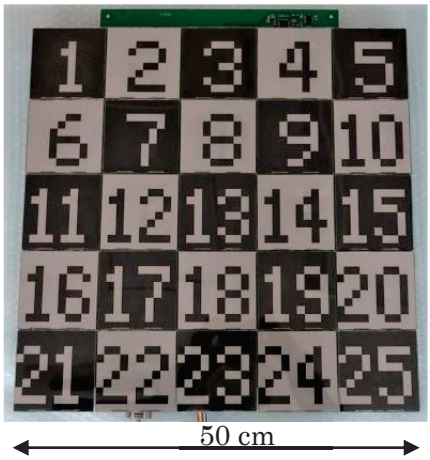
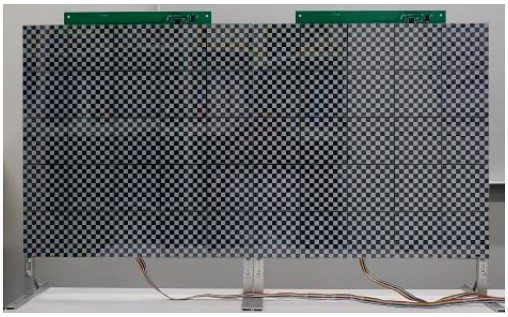
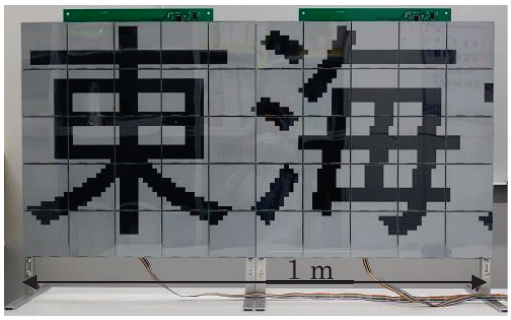


Fig. 4 Arrayed 25 pieces of e-Tiles on a base panel.



(a) Checker pattern



(b) Japanese characters

Fig. 5 Displayed images on e-Tiles.

Table 1 Specifications of e-Tile 2nd prototype.

Item		Specs
Display method		Electrophoretic display
Dimensions		100 mm x 100 mm x 5.5 mm (42 g)
Pixel size		10 mm x 10 mm
Number of pixels		100 pixels / tile
Reflectance		36.6% (white), 3.5% (black) for D65
Contrast ratio		10.5 (white / black)
Image expression		Binary black and white
Driving method		Segmented driving
Base panel	size	500 mm x 500 mm (900 g)
	capacity	25 tiles

3 Evaluation of Influence of the joint gap area

3.1 Aim of evaluation and experimental method

When a large screen is displayed by tile units, joint gap areas are inevitably left between the tiles. The effect of the gap areas on the image quality should be evaluated.

The gap area forms a grid pattern on displayed images. There can be two types of processing schemes for arranging image data.

(1) Hiding: The grid pattern hides a part of the original image and makes it invisible.

(2) No-hiding: Image data is arranged avoiding the grid pattern, and no invisible image area is created.

The advantages and disadvantages of the two schemes are summarized in Table 2.

Table 2 Two types of schemes for arranging image data for tiled display units.

	Advantage	Disadvantage
1)Hiding: The grid pattern hides a part of the original image.	No undesired expansion of displayed image.	Hiding of a certain portion of an original image. Additional processing for removing image data under the grid pattern.
2) No-hiding: Image data is arranged avoiding the grid pattern.	No hiding of an original image. No additional image processing.	Unnatural expansion of displayed image.

3.2 Evaluation methods

Displayed images constructed with 25 tile units (5 x 5 tiles) were simulated and evaluated. Each tile was supposed to have 100 pixels (10 x 10 pixels). Total number of pixels constructed with the 25 tiles were 2500 pixels (50 x 50 pixels). Two types of displayed images are prepared using the two image arranging schemes of (1) Hiding and (2) No-hiding. The grid width [g] was set at a ratio of g/w = 3, 5, 10, 20, 40% to the tile width [w]. The ratio of the gird width to pixel width is automatically calculated 30, 50 100, 200, 400% in this setting. Two colors of grid pattern, black and white, were both tested.

Table 3 and Table 4 shows typical tiled images when g/w =10%. A Japanese character using a font with a 48

x 48 dot configuration was used as a display content, and was printed on plain paper with an inkjet printer. The printed image size was 100 mm square for the “Hiding” arrangement scheme.

Subjects (4 students) were asked to evaluate the image quality with an observation distance of 6.74 m. At this condition, the visual angle for the pixel width on the tile is 0.017°; this angle is generally regarded as the minimum visible angle. Image evaluations were performed by using 5 levels of evaluation scale (Table 5).

Table 3 Typical tiled images **(g/w = 5%)**

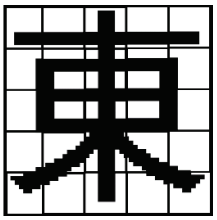
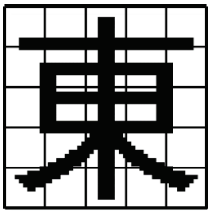
	No-hiding of image	Hiding of image
Black grid		
White grid		

Table 4 Typical tiled images **(g/w = 10%)**

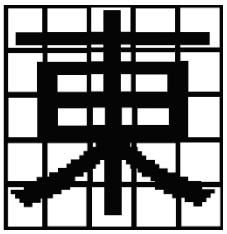
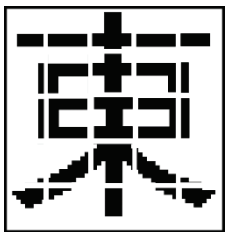
	No-hiding of image	Hiding of image
Black grid		
White grid		

Table 5 Five-level subjective evaluation scale

Score	Subjective evaluation to the sample image
5	No degradation
4	Almost no degradation
3	Obvious degradation
2	Image contents hard to be identified
1	Image contents cannot be identified

3.3 Evaluation results

The evaluation results are shown in Fig. 6 and Fig. 7. When the grid width ratio g/w = 5% or less, the evaluation results for all the 4 conditions reached the highest level 5. Under the condition of g/w > 10%, the “No-hiding” scheme gave a slightly higher evaluation results. The color of the grid pattern did not give a certain tendency to the superiority or inferiority of the subjective evaluation.

It is good news for the tiled displays that the image was evaluated without any degradation even for a relatively large grid width ratio of 5%. This result is reasonable considering the visual angle to the grid width is only 0.0085° when g/w = 5%; this size of narrow grid supposed not to be clearly recognized from the distant viewing position of this study.

In addition, the fact that the “Hiding” scheme tends to be highly evaluated indicates that additional processing for the image data subtraction is unnecessary.

However, this evaluation targets only relatively large character images observed from rather distant position. Further studies are necessary for evaluations of the effect of observation distance and displayed contents.

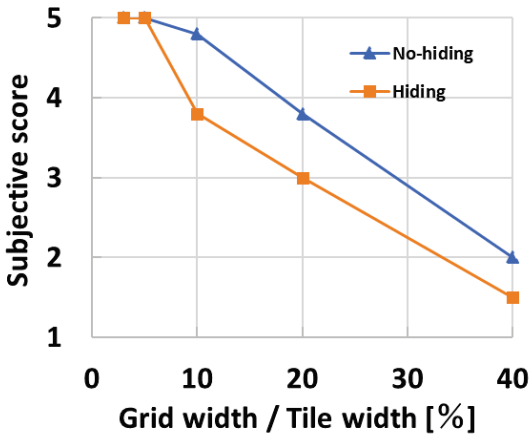


Fig. 6 Effect of grid width to image quality **(Black grid)**

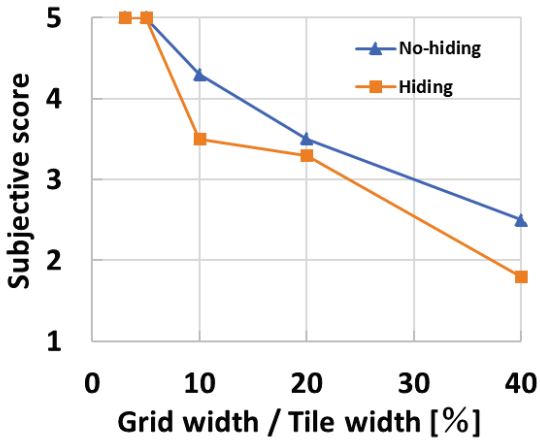


Fig. 7 Effect of grid width to image quality **(White grid)**

4 Conclusions

1) The second prototype of a practical e-Tile that simplifies construction works was developed.
2) The effect of the joint gap area for the 10 cm wide tiled displays, on the image quality, was evaluated by subjective evaluation to the simulated images.

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