Visibility Evaluation of Presentation Slides Based on Human Visual Features

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ABSTRACT

We propose a method to evaluate character images as a part of the study on quantitative visibility evaluation for presentation slides. When authors make slides, characters in the slides need to be designed clear. If images are seen from long distances, they seem to be blurred. It is conceivable that visibility of the images is in proportion to gradients in the images. We simulated long-distance character image by applying a Gaussian filter, and calculated Total Gradient Ratio, i.e. TGR of character images using the Sobel filters. TGR is an index of character contrast and it can show differences of visibility caused by font sizes and font types. So long as they are evaluated quantitatively, compilation of high visibility slides can be made readily.

1. INTRODUCTION

Slides are widely used for presentation of academic meetings and businesses. There are several kinds of application software for making slides, such as PowerPoint and Keynote, which has functions to arrange pictures, tables, and texts in frame of slides. So authors can make designed slides. For good presentation, it is important to make high visibility slides, but making of them depends on sense of the authors. If visibility of slides can be evaluated quantitatively, it is easy to make high visibility slides.

To evaluate visibility of slides, subjective experiments are commonly used. If enough subjects are prepared, it is possible to treat the result as an objective data by statistical analysis. Several studies have been done with such subjective experiments [1] [2]. However human visual performance varies by aging or eyesight, and results are influenced by subjects. Also, more objective evaluation methods are proposed. However there is not enough study for visibility evaluation of presentation slides.

In this paper, we propose a method to evaluate visibility of characters in presentation slides quantitatively.

2. RELATION WORKS

In image engineering and illuminating engineering, it is important to evaluate human visibility. So it is widely proposed some valuation basis of visibility. For example, in fields of web design, World Wide Web Consortium (W3C) [3] shows a tentative plan to evaluate with lightness and chromaticity differences of background color and text color. It can measure not only visibility of general people but also visibility of cataract patient. However, as for presentation slides, they are projected onto a screen, and visual performance on a desktop display is different from that on a screen. Okumura et al. propose quantitative evaluation for visual of presentation slides by color perception simulation in situation of mesopic vision [4]. P. O’Donovan et al. propose a method to evaluate a scheme using three large datasets [5].

Other than color perception, Haraguchi et al. proposed to estimate readability of color texts on a display [6]. This method extends readability evaluation function (VIF) proposed by Iwai et al. [7]. VIF is calculated by font brightness and background brightness, font sizes. This study shows quantitative estimation with high degree of accuracy. However, these studies are for LCD at fixed visual distances, so it is not consideration for influences of visual distances.

There are some studies that aim visibility estimation without subjects. Doman et al. propose a method to estimate visibility of traffic signs with features of several images [8]. For more general evaluation, Saliency map, a computational model of human early visual attention, is proposed to calculate the tendency of human visual attention from images [9].

3. VISIBILITY OF SLIDES

In this section, we explain the factors that affect visibility of slides, and features of font in presentation slides. Figure 1 shows an example of presentation slides.

Figure 1: Differences of Fonts
3.1. FACTORS OF SLIDE VISIBILITY

Visibility of presentation slides depend on several factors. The following factors are major ones.

(1) Visibility of layout
Layout of presentation slide means arrangement of text areas, tables, and images. Visibility of layout depends on the position and size of each block and spacing. Also, visibility of each element should reflect its importance of the content in a slide.

(2) Combination of colors
Combination of colors is treated by prior research [4]. In case of readability of texts in presentation slides, it is important to be distinguishable from individual characters clearly regardless of contents of slides.

(3) Readability of font type and font size
Audiences watch presentation slides from various visual distances. Therefore, it is important to evaluate quantitative visibility of various character fonts from various viewing distances.

3.2. FONTS TYPE AND FONT SIZE

When an author makes presentation slides, a font type must be selected. As a rule of thumb, thick and simple style font types, such as Gothic and Arial, are better than fine style font types with serif, such as Times and Mincho (for Japanese) for presentation slides [10]. Figure 2 shows two font types as Japanese character “あ”. Additionally, it is important to select a font size as presentation slides. Point is a unit of font size, and 1 point corresponds to 1/72 inch. As presentation slides, it is said that a desirable font size is larger than 24 pt. Figure 3 shows several font sizes as Japanese character “あ” in gothic font.

4. LONG-DISTANCE CHARACTER IMAGE

Watching the images from the long distance, they look small and to be faded. We simulate this effect by creating long-distance character images.

4.1. HUMAN VISUAL RESPONSE

Human vision system recognizes characters by detecting light and shade pattern of them. Human visual response depends on spatial frequency, i.e. light/shade change frequency in space. Thus, it affects visibility of characters. The maximum response in human visual system is obtained by the spatial frequency around 6[cycles/deg]. For higher or lower frequency, visual response gradually decreases, so that visual contrast becomes lower.

On an actual presentation screen, this spatial frequency can be considered as follows. Let $\omega$ be the spatial frequency with the maximum response by human vision, then,

$$\omega = 6 \text{[cycle/deg]} = 1080 \pi \text{[cycle/rad]} \quad (1)$$

If this spatial frequency is displayed as a stripe pattern, the period $\lambda$ of the pattern can be obtained:

$$\lambda = \frac{L}{\omega} = \frac{\pi}{1080} L \approx (2.9 \times 10^{-3}) L \quad (2)$$

where $L$ is the distance between the observer and the screen.

4.2. FILTER FOR VISUAL SIMULATION

In order to simulate the image that the human visual system captures, the best way is to apply a filter with the response function of human vision. For the simplicity, a Gaussian-filter is used instead in our research. Gaussian-filters are a kind of low-pass filters, and cannot reduce low frequency component. However, it is not a major disadvantage since our main interest is the visibility of small characters i.e. high frequency component.

In the Gaussian-filter defined by (3),

$$G(x,y) = \frac{1}{2 \pi \sigma^2} \exp \left(-\frac{x^2 + y^2}{2\sigma^2} \right) \quad (3)$$

where $\sigma$ defines the cut-off frequency of this low-pass filter. Assuming that the range of Gaussian distribution in $\pm 3\sigma$ corresponds to the period of a stripe pattern, $\sigma$ is obtained as follows:

$$\sigma = \frac{\lambda}{6} \quad (4)$$

4.3. SIMULATED IMAGES

We apply the Gaussian-filter to character images. The character images are created by Microsoft Office PowerPoint 2007, are converted to BMP. Then, simulated long-distance character images can be obtained by applying the Gaussian filter with the
appropriate $\sigma$. In this paper, we use 6 kinds of parameters ($\sigma=0.8, 1.6, 2.4, 3.2, 4.0, 4.8$) on the assumption that a presentation slide projected onto a 120 in. screen is viewed from an observer. Figure 4 shows some examples of simulated long-distance character images.

Figure 4: Simulated long-distance character image, which are Gaussian-filtered the image of “あ” (The type of fonts: Gothic, size of fonts: 44pt)

5. INDEX OF CHARACTER CONTRAST

In this section, we propose a quantitative index which evaluates overall contrast of each character in presentation slides. We use the summation of gradient magnitude of character images.

5.1. CONTRAST BY TOTAL GRADIENT RATIO

In presentation slides, visibility of each character depends on the contrast between character stroke regions and background regions. When it is observed from a long distance, the simulated character image becomes blurred. However, if the contrast between stroke / background regions is high enough, i.e. center of each stroke region is black enough and center of each background region is white enough, the observer can easily recognize the character. On the contrary, if the center of each region becomes gray, the contrast reduces and it becomes harder to recognize the character.

To evaluate this kind of contrast for each character quantitatively, we propose an index based on Total Gradient Magnitude (TGM). The TGM is the summation of gradient magnitude value at each pixel in a character area. Suppose there is one line stroke with certain thickness and apply a Gaussian filter. The TGM does not change if the center pixel of the stroke keeps pure black. If the Gaussian filter affect the center pixel and the color becomes closer to the background, the TGM reduces.

Figure 5 shows the effect of TGM in 1 dimensional case. In an original character image, intensity changes at each edge as a step function (Fig. 5 [A]). By applying Gaussian-filter, intensity changes as a slope. If the maximum intensity in background is pure white and minimum intensity in character stroke is pure black (Fig. 5 [B]), TGM around each edge is the same as that in [A]. In this case, the observer can distinguish each stroke of character from background even if edges are blurred. However, if $\sigma$ of Gaussian-filter become larger and the maximum intensity decrease and/or the minimum intensity increase (Fig. 5 [C]), TGM also decreases. Here, it becomes harder to distinguish each stroke.

Thus, we can evaluate the contrast of each character by taking the ratio of the TGM of simulated long-distance character image to the TGM of original character image. We call this ratio “Total Gradient Ratio (TGR)”. The TGR is a value between 0 and 1, and higher TGR value means higher contrast.

Figure 5: Intensity curves of blurred characters

5.2. RATIO OF EDGE GRADIENTS

We calculated the TGR of each character with the Sobel filters. The procedure is as follows.

Step.1 The original character image is enlarged twice by nearest neighbor method. This is due to the characteristics of the Sobel filters. Since the Sobel filters have $3 \times 3$ kernel, TGM cannot be calculated consistently for 1-pixel-width strokes.

Step.2 Gradient $x$- and $y$-components at each pixel $\Delta_x f(x, y), \Delta_y f(x, y)$ are calculated with the Sobel filters. The TGM of the original character image, $E$, is calculated as follows,

$$E = \sqrt{\left(\Delta_x f(i, j)\right)^2 + \left(\Delta_y f(i, j)\right)^2} \quad (5)$$

Step.3 The simulated long-distance character image is created by using a Gaussian filter, and the TGM of the image, $E_{\sigma}$, is calculated by the same way as step 1 and 2.

Step.4 The TGR is calculated as $E_{\sigma}/E$. 

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6. RESULTS

We calculated the TGR values for several characters, and examined the visibility of the character images by font size, font type, and visual range.

6.1. DIFFERENCES OF FONT TYPES

As an example, we investigated visibility of the character image “あ” with the proposed method, and compared results of two font types. Figure 6 shows the TGR of gothic fonts, figure 7 shows the TGR of Mincho fonts. X-axis expresses visual ranges, and Y-axis expresses the TGR, and color shows the size of fonts. In either cases, the TGR decreases with the visual range, however the TGR of Mincho fonts is less than that of gothic fonts. Furthermore, font sizes of 20pt. and more tend to be a similar decline in gothic fonts, by contrast, any font sizes tend to be a similar decline in Mincho fonts. In general, it is said that font sizes of less than 18pt. are inadequate to use at a presentation slide. In conclusion, it is considered the TGR shows differences of visibility in font types quantitatively.

6.2. COMPLICATED KANJI CHARACTER

Figure 8 shows the TGR of “量” in gothic fonts. Compared to “あ”, TGR values are remarkably small in any sizes. This is caused by clouding of character strokes, In such a complicated character, adjacent strokes are very close and look merged from a long distance. This result means that our method can show a tendency of visibility in the character images.

7. CONCLUSIONS AND FUTURE WORKS

In this paper, we have proposed the method to evaluate character images by TGR. This method can show differences of visibility in font types quantitatively, and a tendency of visibility in the character images. However the relationship between the actual human visual and the TGR has not been clarified. In the future we will examine it by subjective test, and validity of this method is verified. Furthermore, we will extend this method to be able to apply other components of slides, establish the method to evaluate presentation slides quantitatively.

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