

A Method for the design of the Font

(An example of the Font KATAKANA for the line printer)

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1. Let's define the coordinate (a_x, a_y) of the centroid of a character by

$$a_x = \frac{\iint_R x f(x, y) dx dy}{\iint_R f(x, y) dx dy} \quad (1)$$

$$a_y = \frac{\iint_R y f(x, y) dx dy}{\iint_R f(x, y) dx dy} \quad (2)$$

and define the spread of the character by

$$\sigma = \sqrt{\frac{\iint_R \{(x-a_x)^2 + (y-a_y)^2\} f(x, y) dx dy}{\iint_R f(x, y) dx dy}} \quad (3)$$

where R is a region containing the character, and $f(x, y)$ is the character function defined below,

$$f(x, y) = \begin{cases} 1 & \text{if } (x, y) \text{ belongs to black part,} \\ 0 & \text{if } (x, y) \text{ belongs to white part.} \end{cases}$$

On the design of the font, the authors have recommended to use a_x and a_y as an evaluation of the legibility and the stability of characters in arrangement and to use σ as the sensuous evaluation of the character size [1]. The recommendation was adopted by the concerned group and the authors had an opportunity to apply it to design the font of KATAKANA (a group of Japanese letters) for the line printer. The essentials are presented in this paper.

2. On the design of the font for the line printer, the following four restrictions were set.

- i) The minimum size of rectangles which contain the whole character center-lines is 2.38 mm by 1.54 mm.
- ii) The standard value of the stroke width is 0.35 mm.
- iii) The stroke width must be kept between 0.20 mm and 0.50 mm.
- iv) The difference quantity r between any two character, which is defined in ISO/TC 97/SC 3-WG 1, is not smaller than 50.

3. First the values of a_x , a_y and σ were calculated concerning the primary font of KATAKANA which was designed under the condition i) by professional lettering designers, where the stroke width of characters was 0.28 mm.

Fig. 1 shows the horizontal and vertical centroids of primary font.

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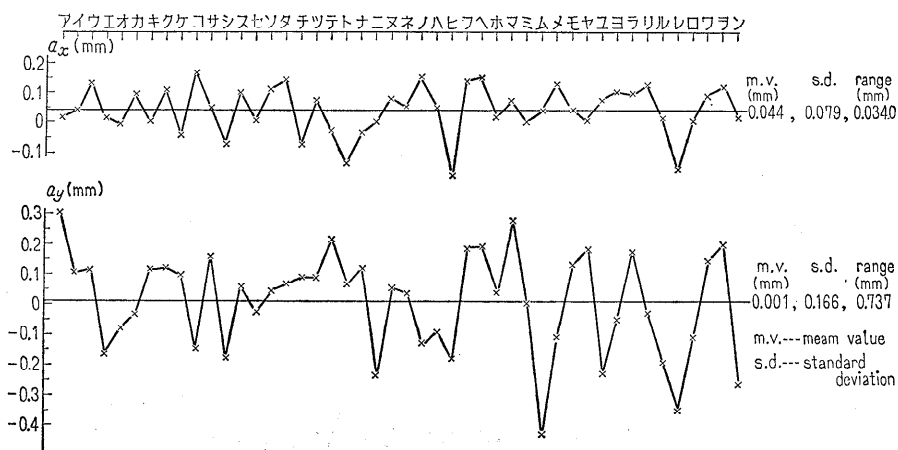


Fig. 1 The horizontal and vertical centroids of primary font.

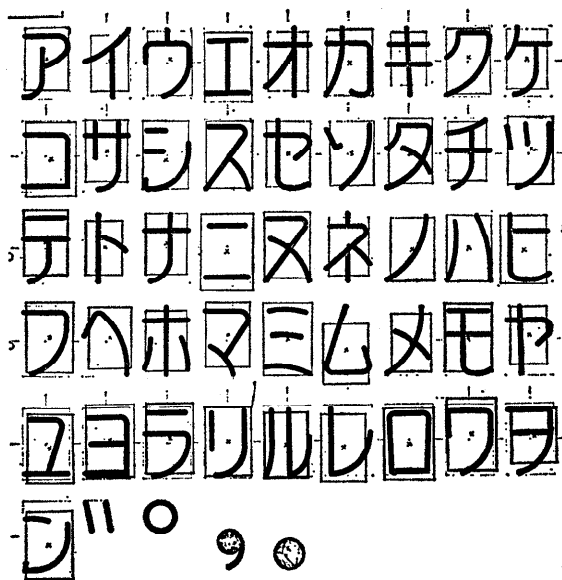


Fig. 2 The definition areas of the primary font.

Fig. 2 illustrates the definition areas of the primary font. In Fig. 2, rectangles are the definition regions of characters, which are defined so that the length of the side line is proportional to σ , the central point of the rectangle coincides with the centroid (a_x, a_y) , and the ratio of the horizontal length to the vertical length is $2/3$ for all rectangles.

The value of a_y distributes more widely than those of a_x , as shown in Fig.

1. The ratio of the standard deviations of a_y to that of a_x is larger than $3/2$.

The smallest three values of σ are observed by the characters 'キ', 'ト', and 'メ'.

Since characters are printed horizontally, special attention was given to a_x among the three quantities a_x , a_y and σ . When characters are printed by a line printer, the horizontal distance between any two successive characters should be constant. Therefore it seems "agreeable for eyes" in our experiences that all a_x 's are of much the same value. Moreover, this will be also useful for the recognition by machine.

4. For the reasons above, character figures with large $|a_x|$ on the primary font were modified. The modifications of character shapes were tried again and again with a balance of the font being kept, until they satisfied the conditions iv) and v) below.

v) When the character stroke width is 0.35 mm, any $|a_x|$ is not larger than 0.150 mm.

アイウエオ カキクケコ サシスセソ タチツテト ナニヌネノ

ハヒフヘホ マミムメモ ヤユヨ ラリルレロ フラン

Fig. 3 The final font of a real size.

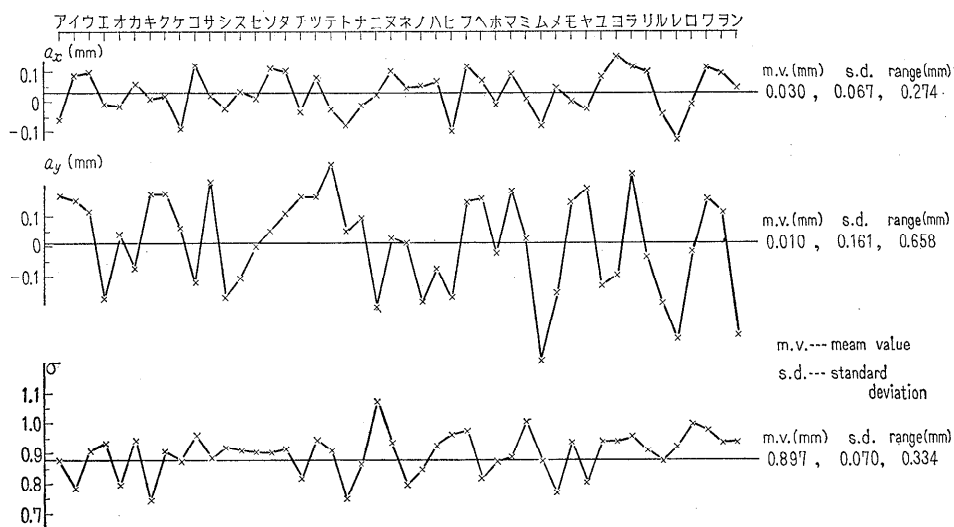


Fig. 4 Horizontal centroid, vertical centroid and the spread of the final font.

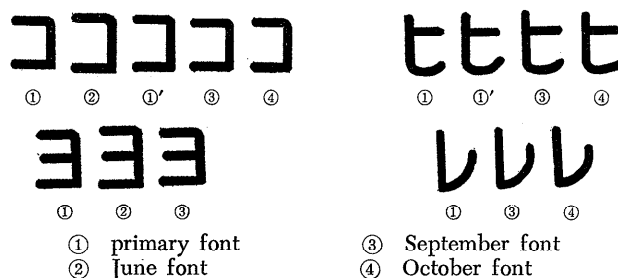


Fig. 5 Characters with large $|a_x|$.

コノヒロイウミ
コノヒロイウミ

Fig. 6 Example of modified fonts. Upper sentence is written using font presented in June. Lower sentence is written using the font present in October.

Fig. 3 represents characters in the final font of a real size. Their stroke width is 0.35 mm. They satisfy, of course, the three conditions i), iv) and v).

Fig. 4 shows horizontal centroid, vertical centroid and the spread of final font.

Fig. 5 shows characters with large $|a_x|$.

Examples of modified fonts are shown in Fig. 6. Upper sentence is written in the font presented in June, and lower sentence in the font presented in October.

As shown in Fig. 2 and Fig. 4, standard deviations and ranges of a_x , a_y and σ in the final font are smaller than those in the primary font. The mean value of a_x in the final font is positive (0.030 mm). On the contrary, the mean value of a_x in the OCR-B upper case letters is negative (-0.041 mm). This fact suggests differences between Japanese letters and Roman letters.

Reference

- [1] Iijima, T., I. Yamazaki and M. Yoshimura, On the Centroid and the Spread of Character Figure, *Joho Shori*, 9, 5 (1968), 277-284.