Approach to UD Font (Universal Design Font) Development

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Abstract

According to the current progress of IT technologies in society, the need to employ universal design (UD) in information devices is being emphasized so that more people can easily and comfortably use them. In order to meet such needs, the authors have conducted research and analysis of fonts that are "easy to see" and "easy to read" for all, when they use information devices. According to these researches and analyses, we have defined four requirements and have developed our original fonts according to user-centered design (UCD) precepts in order to satisfy these requirements. From the results of the verification experiments, we have confirmed the effectiveness of these fonts in satisfying UD precepts and for achieving acceptable "easy to see (visibility)" and "easy to read (readability)" characteristics. This paper introduces our approach and the resulting new fonts.

1. Introduction

In accordance with the advancing IT society, the increasing number of digital divide issues had been anticipated. It is not exceptional in the information device market. The demands for employing universal design (UD) precepts in designing information devices will be of benefit for more people by enabling the devices to be used more easily and comfortably.

Text messages are still the main method of conveying information. In such an environment, it is very important to consider the employment of UD concepts for fonts because they embody texts.

Therefore we have been developing our UD fonts to be optimally suitable for display with information equipment and devices. This paper introduces our approach to such development and the results of the relevant verification experiments.

2. Selecting Process of the Developed Font

The Gothic font is generally the one employed on display equipment. There are greater limitations to reproducing characters on a display panel than in printing, this is due to the resolution and brightness criteria. The Gothic font features a certain line width for the horizontal and for the vertical strokes, so that it can be sharply displayed in the frame of characters

Fig. 1 Comparison of reproducibility between Gothic and Minchou fonts.

when shown on a display panel. It has an advantage in reproducing the form of characters. As shown in **Fig. 1** , when comparing the *Minchou* font (Ming-style typeface) and the Gothic font, the Gothic font reproduces characters more clearly. Therefore, we decided to employ the Gothic font as suitable for modification into our UD font.

3. Developmental Research and Analysis

In order to collect and understand user information, we conducted a survey to find factors that determine users' requests for font "visibility" and "readability." First, we collected Gothic fonts (both Japanese and European) that are the most used in the fonts markets, and then we analyzed them to find the following features that could be found commonly among both Japanese and European Gothic fonts.

1) A design that achieves smooth eye movement with horizontal layout (Readability)
2) A design containing a lot of space (Visibility)

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3) Adequate line thickness gives evenness of black color in the characters (Visibility)

4) A design to avoid misreading or misrecognition (legibility)

When considering the issues of "ease of seeing" and "ease of reading," the above four factors can be the common factors for the font design to meet the UD concept (readability, visibility and legibility).

Further improvements, based on the results of the user evaluations, have been undertaken to the traditional Gothic fonts in accordance with the specifications of various information devices. We then found the following requirements after analyzing these improvement requests.

1) *Hiragana* and *Katakana* should be of a larger size. (Visibility)

2) *Dakuten*[*1] and *Han-dakuten*[*2] should be clearer. (Display adequacy)

3) Distinction between "0 (zero)" and "O (capital letter of "o"), as well "I (capital letter of "i") and "l (small letter of "L"). (Legibility)

4) Preventing illegible Chinese characters due to too many strokes. (Visibility)

5) Simple design is favorable. (Visibility and display adequacy)

As you can see, the above requirements include the "display adequacy" issue. "Display adequacy" has to achieve good reproducibility of characters on a display device. We then acknowledged the necessity for more improvements of the "display adequacy."

Finally we defined the four following key points that are necessary for UD fonts, and we then proceeded to our font development.

1) Readability: Ease of reading sentences and group of characters.

2) Visibility: Ease of identifying each character distinctly.

3) Legibility: Distinctly identifying a character in order to prevent the misreading of another similar looking character.

4) Display adequacy: High quality reproducibility of characters on a display device.

4. Features of the Developed Fonts

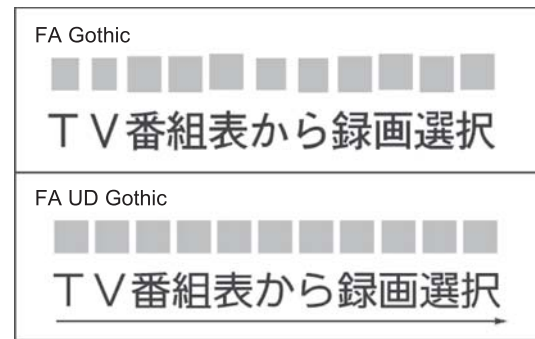By setting the above four key points as our goals, we have

Fig. 2   Comparison of text characters, readability.

developed a new font and named it the "FA UD Gothic".

There follows a detailed explanation of the above four key points (1 Readability, 2 Visibility, 3 Legibility and 4 Display adequacy) that are essential for UD fonts.

(1) Readability

Readability means the ease of reading sentences and groups of characters. How easily people can read sentences or a group of characters depends on the smoothness of their eye movements. One of the factors that disturb eye movements is an imbalance in the size between Chinese characters and Japanese *Kana* . Moreover, most of the information display devices employ horizontal typesetting, and they hardly ever employ vertical typesetting. Therefore, we pursued the maximum readability on a horizontal typesetting display by optimizing the size ratio of Chinese characters and Japanese *Kana* in the horizontal typesetting.

As shown in **Fig. 2** , our FA UD Gothic font (lower) is less irregular compared to the traditional Gothic font (upper). This results in smooth eye movement in the horizontal direction and stress free reading.

(2) Visibility

Visibility means the ease of identifying a character distinctly. Visibility and the clearness of each character depend on the balance in the blackness of the strokes that make up a character, and also of the balance of the space contained within a character. The imbalance of strokes may cause illegibility and untidiness because the strokes are either too close together or they contact each other. Moreover, the less space contained within a character makes a character look smaller than its real size.

[*1] *Dakuten* ("dot dot"): A diacritic sign most often used in the *kana* to indicate that the consonant of a syllable should be voiced.

[*2] *Han-dakuten* ("circle"): A diacritic sign used with the *kana* for syllables starting with *h* to indicate that they should be instead pronounced with [p].
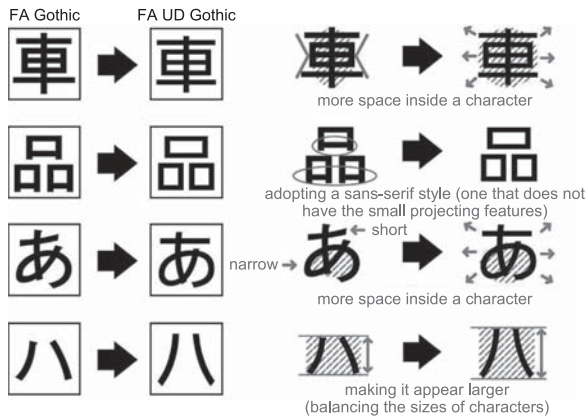
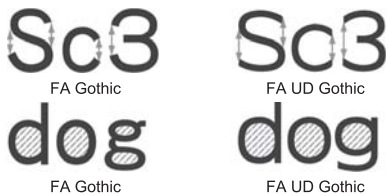Fig. 3   Comparison between our FA UD Gothic font and traditional Gothic font (Chinese characters and Japanese Kana).

Fig. 4   Comparison between our FA UD Gothic font and traditional Gothic font (Alphanumeric characters).
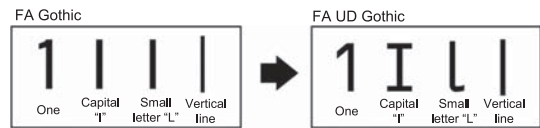

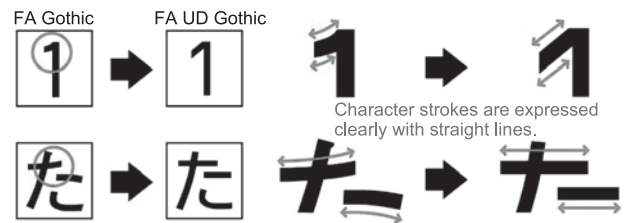Fig. 5   Font design comparison (Difference between similar characters can be seen after providing modifications).

Fig. 6   Font design comparison (Different element processes).

In order to solve these issues, we optimized the arrangement of strokes and made the character design as simple as possible so that we could create fonts that presented better visibility.

Fig. 3 is the comparison between our FA UD Gothic font and traditional Gothic font with samples of Chinese characters and Japanese *Kana* . Our FA UD Gothic font achieved clearer and larger size impression due to the font design we have developed, such as more space inside a character, making it appear larger, adopting a sans-serif style (one that does not have the small projecting features).

Fig. 4 is a comparison between our FA UD Gothic font and the traditional Gothic font with samples of alphanumeric characters. By giving more space in the areas indicated by the arrows and the shaded area in Fig. 4, visibility has been improved and a clearer impression has been given, as did the Chinese characters and Japanese Kana in Fig. 3.

(3)Legibility

Legibility is the capability of identifying a character and not misreading it as another similar looking character. To prevent the misreading of characters, it is necessary to deliberately modify those characters that have similar appearances.

However, if a character is modified too much, it maybe become difficult to identify which character it is intended to be and sometimes it may become illegible. Therefore, it is important to consider both visibility and legibility in modifying a character.

Fig. 5 shows the modification of characters of similar appearance and their comparisons.

(4)Display adequacy

Display adequacy means the reproduction facility of characters on display devices. The reproducibility of characters on a display device depends on various specific display criteria. Especially when characters are displayed on a display device with low resolution or on a small sized display screen, a more jagged and partially agglomerated appearance that degrades the reproducibility becomes evident. In order to solve such issues, we have examined a font design that is not influenced by the quality of the display device. As shown in **Fig. 6** , the stroke that was expressed with a curved line was changed into a simple straight line so that the jagged edge of a character stroke could be suppressed as much as possible.

5. Evaluation and Verification

We provided user evaluation to our FA UD Gothic fonts to

examine "visibility" and "readability" for all kinds of persons. The verification experiments have also been conducted to acquire unbiased opinions as much as possible in order to give more reliability to the results of the evaluation and verification.

5.1 Experiment Targets

(1) Examinees
- 10 healthy young persons (male and female in 20's) with no visual impairments.
- 10 healthy but elderly persons (male and female around 70's) with no visual impairments.

(2) Examined fonts
- FA UD Gothic, 3 fonts of other manufacturers, another NEC font. All of these fonts are Gothic and of almost the same stroke thickness.
- Among the three fonts of other manufacturers, two of them were developed from a UD perspective and the rest as a conventional Gothic typeface.
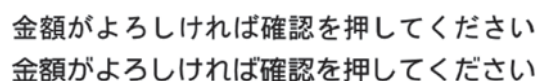
5.2 Experimental Method

The purpose of these user evaluation experiments is to check the design adequacy of our FA UD Gothic font, and the superiority of its four key points that are essential for UD fonts (1 Readability, 2 Visibility, 3 Legibility and 4 Display adequacy).

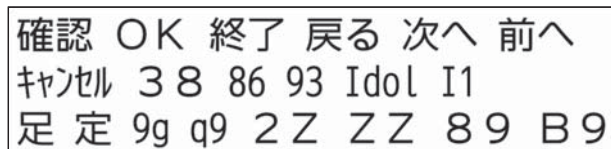**(1) Experiment 1: Evaluation of visibility**
The same sentences are displayed, but one is with FA UD Gothic font and the other is one of the other examined fonts. These are displayed on a display device in order to compare and evaluate their "visibility" and "design superiority" (**Fig. 7**). Also experiments have been conducted with the following conditions: different character types (combinations of one-byte alphanumeric, two-byte Chinese characters, *Katakana* and numbers, and two-byte *Hiragana* and Chinese characters), positive (black letters on a white background) and reverse (white letters on a black background) displays, and changing the positions of sentences (upper and lower).

These experiments have each been conducted 240 times in

Fig. 7　Sample sentence for experiment 1.

Fig. 8　Sample characters for the experiment 2.

Photo　Experiment scene.

order to check "visibility" and "design superiority."

(2) Experiment 2: Evaluation of legibility under adverse conditions
As a supplement to the Experiment 1, an evaluation of legibility under adverse conditions has also been conducted. In order to measure the percentage of readability, seven groups of characters that are often used for input operations on a display screen and thirteen characters that are easily misread (**Fig. 8**) were randomly displayed for a short period (40 ms). The results of the experiment conducted among young examinees do not usually show much variability. Therefore we asked them to wear pseudo-cataract experience goggles to degrade their visual conditions for this experiment (**Photo**). The experiments were conducted under the conditions of both negative and positive displays. The total number of experiments undertaken with the examined fonts was 280 for the "characters for input operations" evaluations and 520 times for the "easy to misread characters" evaluation.

5.3 Evaluations and Verifications Results

(1) Results of Experiment 1
Fig. 9 shows the total evaluation results of the Experiment 1 for "visibility" and "design superiority" conducted among
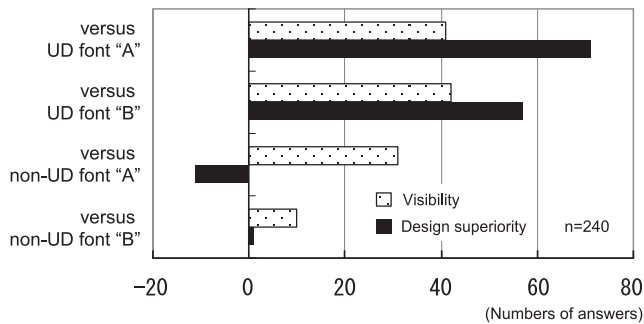
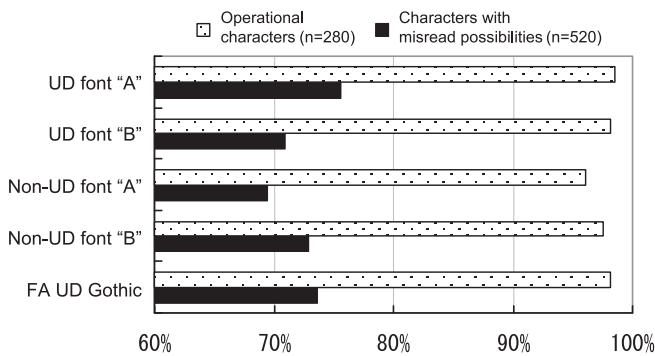Fig. 9   Results of experiment 1: Superiority level of FA UD Gothic.

Fig. 10   Results of experiment 2: Percentage of correct answers.

groups of both young and elderly persons. The horizontal axis in Fig. 9 indicates the difference in the number of answers of examinees who scored that FA UD Gothic is superior to the other fonts and of examinees who thought that fonts other than FA UD Gothic were superior. The higher the graph shows the more superior that the FA UD Gothic is, compared to the other examined fonts.

(2) Results of Experiment 2

Fig. 10 shows the total evaluation results of the Experiment 2 conducted among the groups of both young and elderly persons.

The result shows that the most successful font at preventing misreading is the UD font "A," which is followed by the FA UD Gothic. A significant result does not appear in the characters to be used for input operations. This is because the characters to be used for operations are mostly common words so that examinees could easily guess these characters. On the other hand, the significant difference in correct answer percentages could be seen among fonts evaluated in the misreading tests.

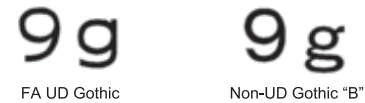FA UD Gothic   Non-UD Gothic "B"

Fig. 11   Experiment samples: Number "9" and small letter "g."

This is because the font design considerations for visibility and legibility could be reflected in the results. However, for the font shown in **Fig. 11** , the non-UD font "B" acquired the higher percentage of correct answers than the FA UD Gothic. A design focusing on "visibility" was adopted for the lower case letter "g" with FA UD Gothic (see Fig. 4) However, this attempt worked unfavorably in the legibility test, as the lower case "g" could be misread as the number 9.

5.4 Analysis (Consideration)

After analyzing the results of the Experiments 1 and 2, we have confirmed that FA UD Gothic has been designed appropriately in overall aspects, and it is highly competitive against other existing fonts.

At the same time, we have found issues that remain to be solved in the future. We have conducted the Experiment 1 to evaluate total superiority of font design work and to thereby achieve the previously mentioned four key points. However, the results of comparisons with other fonts showed that examinees were influenced also by factors other than by these four key points, such as thickness of the character strokes and the space between the characters, etc. Moreover, understanding of the evaluation values for "visibility" and "design superiority" were different for each examinee. For improving experiments and evaluation methods in the future, examinations based on the results acquired from this time will be essential.

Moreover, the Experiment 2 showed that for an attempt to be beneficial for one aspect could some times work unfavorably for another aspect. For example, a font designed for visually impaired persons could degrade the readability for non-visually impaired persons. When developing new fonts in future, it will be necessary to consider the balance between the design issues and various other potential factors, and to then prepare several design proposals according to the peculiarities of each device.

6. Conclusion

Our approaches to UD font development by employing UCD

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methods and the results of evaluations and experiments are explained in this paper. The developed FA UD Gothic fonts are now employed as texts for various operations menus such as for digital TVs, car navigation systems, mobile phones, etc. including Android terminals. When fonts with superior visibility are more widely applied for displays, the communication using information terminals will be accelerated. This will result in the production of less printing matter, so that a reduction in the environmental load can be expected.

We will develop superior design and evaluation methods to create highly competitive fonts.

*Android is a trade mark or a registered trade mark of Google Inc.

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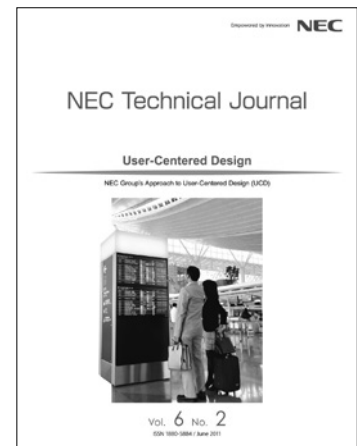
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