Title:
Design and Evaluation of Handwritten Traditional Chinese Fonts Reflecting Human-like Writing Characteristics via Computer-Mediated Communication

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Introduction:
Handwritten messages often provide a personal touch that enhances the communication. However, this personal element is typically absent in computer-mediated communication. When writing letters, postcards, or memos, both the words and their presentation reflect and express one's personality and emotions at the time of writing. Consequently, the handwriting style of an individual can significantly enhance the efficacy of text communication. However, with the advances of digital technology, email and now social media have replaced handwriting with computer fonts and emotional expression with emojis or stickers. However, it remains uncertain whether computer-generated graphics like emojis or stickers can truly convey one's feelings [1].

Various handwritten fonts have been developed, and nowadays it is possible to create a personal font using different methods that reflect an individual's handwriting style [2] [3]. However, the advantages of computer-generated text, such as precision and consistency, contrast with the unique characteristics of human handwriting. The handwriting differs in size, stroke, and ink color due to variations in writing speed and pressure. It is reasonable to state that humans can't write the same characters identically. Inconsistency is therefore identified as a key characteristic of handwriting. In this paper, we present an innovative method for creating personal handwriting fonts that capture the natural variability found in human handwriting.

The prototype features a program for creating writing paper with grids for Chinese characters, an algorithm to convert scanned handwritten characters into fonts, and software to embed rules into these fonts. These fonts can be installed in word processors like Microsoft WORD to display different glyph styles for consecutive identical characters, mimicking human inconsistency. Various users were invited to create their personalized fonts using our prototype, and a perceptual experiment was conducted to demonstrate the effectiveness of inducing the perception of human-like handwriting.

Main Idea:
OpenType fonts offer several features that allow them to select different glyph styles for the same character. It was initially developed to demonstrate the graphical presentation for English calligraphy, such as ligature substitutions for unique double "dd" glyphs to “dd ”, and contextual substitution for flourishes in specific locations, such as “fragile ”. This paper employs contextual substitution to exhibit different styles of individual characters in a handwriting font. The font retains various glyph styles for certain characters and displays them according to rules defined through programming.

We developed a prototype called InkFontify using Python [4]. The two purposes of InkFontify were to create writing papers and to create handwriting fonts from the digital images of the writing papers.

Fig. 1 illustrates the workflow of the InkFontify. InkFontify had four functions, the first of which created writing papers. After scanning the finished writing paper to digital images, the second one would adjust the orientation of the images. The third one cropped every character to a single image. The fourth one converted images of the characters to a font file. The font editor FontForge was used to access the OpenType feature [5].

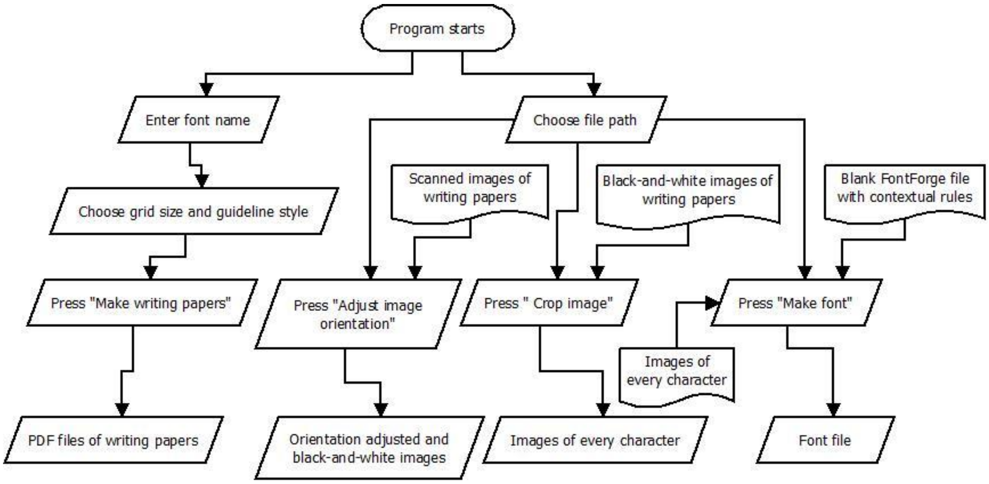

Fig. 1: Flowchart of the InkFontify.

Fig. 2(a) shows the interface of the InkFontify. The user first enters the name of the font, then selects the grid size (8, 10, or 12mm), and the guideline style (none, four-square, or nine-square). The prototype will create three sets of writing papers based on the specified settings in PDF format. Fig. 2(b) illustrates an example of the output writing paper. The page features grids with a size of 10 mm, with each page containing a total of 240 grids. The character that needs to be written is displayed at the top of each grid. A QR code is located at the bottom left to assist InkFontify in calibrating the scanned handwritten paper for further analysis and processing.

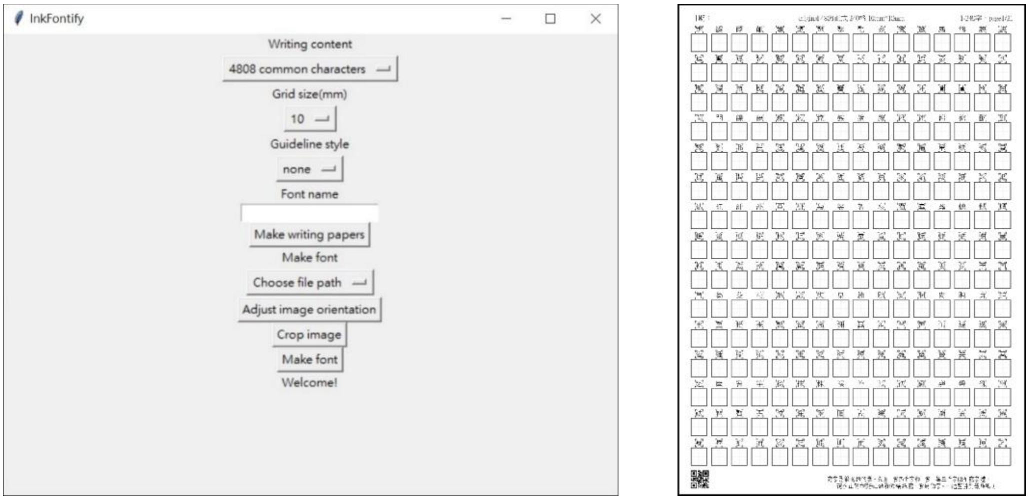

Fig. 2: (a) The InkFontify interface illustrates the workflow, (b) Sample output writing paper.

The typical writing paper for practicing Chinese Brush Calligraphy is preformatted with square boxes, each subdivided equally into a 3 by 3 grid with a total of 9 smaller squares. An initial survey on handwriting using a pen, pencil, or fountain pen—primarily for communication rather than artistic purposes—reveals that when writing Chinese characters freehand, the characters are often taller than they are wide, as shown in Fig. 3. The width-to-height ratio consistently remains less than 1. To accommodate this, the preformatted grid in InkFontify utilizes a rectangular box with a 9:10 ratio.

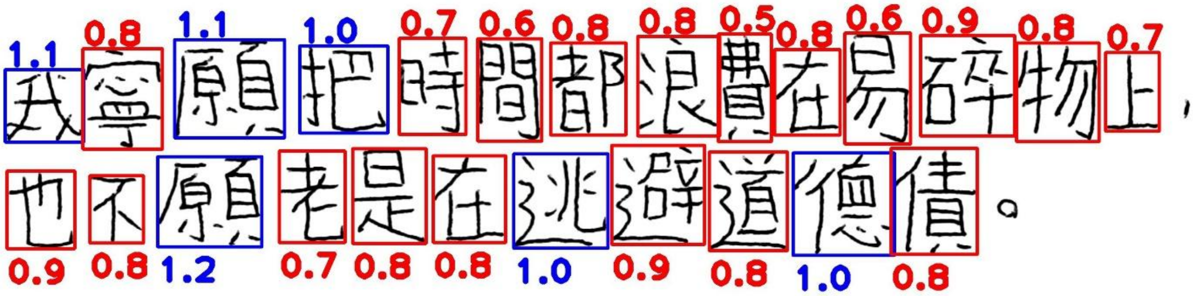

Fig. 3: Example of height-to-width ratio for handwritten Chinese characters.

To achieve varied styles for the same character, the content needs to be written repeatedly to create human-like inconsistency. Although some methods can generate Chinese characters from a few samples, creating one's handwriting font makes it more personal and likable. The three sets of writing papers had the same basic writing material, but each set had different character selection ranges and sorting methods. The basic writing material was the 4808 commonly used Traditional Chinese characters, for instance, "門 (door)" and "快 (fast)," defined by the Ministry of Education [6]. The first set of writing papers contained all characters from the basic writing material, sorted by frequency in ascending order. Because handwriting improves with practice, writing high-frequency characters, for instance, "我 (I)" and "有 (have)," later will result in a more refined font. The second set of writing papers contained the top 520 characters from the basic writing material, sorted by frequency in descending order. Because high-frequency characters tend to reoccur, various glyph styles are needed to prevent repeated glyphs. The third set of writing papers contained the top 200 characters from the basic writing material, sorted by frequency in descending order. Thus, some characters only have one style, while other characters have two or three styles.

To create a personalized, human-like font, users must complete three sets of writing sheets and scan each page, saving them as digital images, as illustrated in Fig. 4(a). The InkFontify generates three empty folders, one for each set of writing sheets, to organize the scanned images. It detects the QR code on each image to determine the page number, identify the horizontal lines of the QR code, calculate their tilt angle, and adjust the image orientation accordingly. As illustrated in Fig. 4(b), the image is binarized and saved as a new file.

Each character on the scanned page image must be saved as an individual image. The InkFontify detects the grids for each character and crops them accordingly. Since many Chinese characters, such as 口 and 國, have a square-like structure, the grid size is carefully constrained during detection. The size of the QR code matches the height of the grid. The prototype detects the QR code size and identifies grids with the same height. As illustrated in Fig. 4(c), the prototype detects the grids and marks them with red hollow squares. Each grid is then cropped into an individual image.

When writing a sentence, there is a tendency for sequential characters to gradually shift, causing the sentence to tilt at an angle unconsciously. The angle might be minor or hardly noticeable in the original handwriting, but when the characters are extracted and rearranged in a new order, the resulting line may exhibit a zigzag pattern.

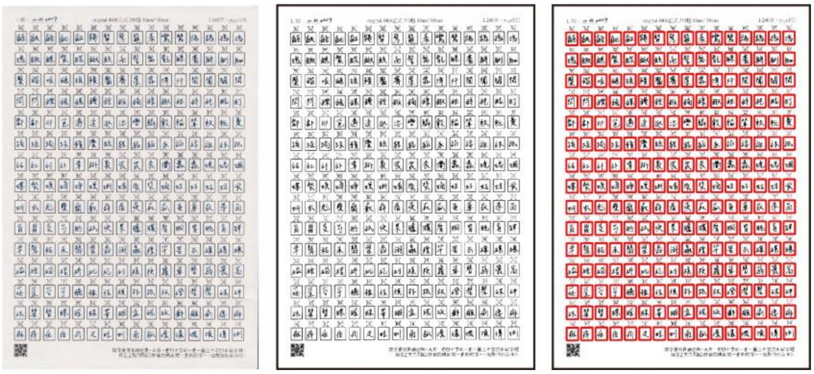

Fig. 4: (a) scanned image, (b) orientation and color adjusted, (c) grid detected.

Field tests revealed that the aforementioned handwriting tendency is also evident when users fill in the grids on the writing paper. The written characters are not always perfectly centered within the grid when saved as individual images. To create a font that is comfortable to read when characters are combined in various ways to form sentences, the center of mass for each character must be aligned.

Fig. 5 illustrates the solution: after each font is cropped from the scanned page, InkFontify detects and calculates the center of mass of every stroke in the character (marked as red dots in Fig. 5). The overall center of mass of the character (marked as a blue dot in Fig. 5) is then determined by calculating the center of mass of all the red dots.

Fig. 5: Calculation of the center of mass in a character.

(a) (b)

Fig. 6: Comparisons of the sentence without (a) and with (b) the adjustment of the center of mass.

The images of each character are then converted into SVG files and imported into a blank FontForge file. Non-repeating characters are placed in their corresponding slots, while new slots are created for repeating characters. The OpenType feature is accessed through the lookup function in the file.

The lookup function includes two single-substitution files and one contextual-chaining substitution file. Each single substitution file includes a list of repeating characters with the same variation number: variation 1 of the repeating characters is placed in the first single substitution file, and variation 2 is placed in the second single substitution file. The contextual substitution contains rules that determine which variation style will be displayed. The file includes two rules: "x | x@<1> |" and "x | x@<1> x@<2>|". The first rule means that if there are two characters in a sentence, and the first character uses the original style, the second character will display in variation 1 style. The second rule means that if there are three characters in a sentence, the first character will use the original style, the second character will use variation 1, and the third character will use variation 2. The prototype then exports the FontForge file as a TrueType file.

The InkFontify was tested by twenty participants, resulting in the creation of twenty handwriting fonts. Each participant received three sets of writing papers and instructions. After completing the writing, they returned the papers to the researcher. The researcher then used the prototype to create handwriting fonts and sent them back to the participants. As shown in Fig. 7, the font automatically selects the appropriate glyph when repeat characters appear in a sentence. Characters marked with solid squares (字) represent "words," with each character choosing a different glyph style.

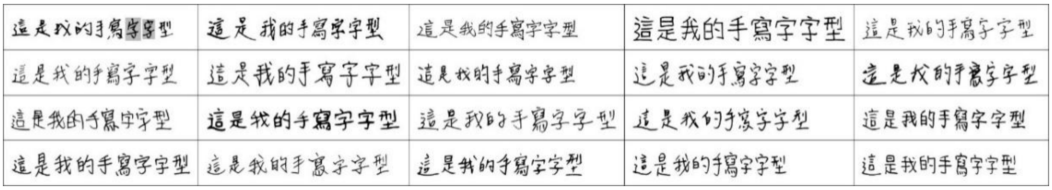

Fig. 7: Twenty fonts created by the prototype.

<u>Evaluations:</u>
An experiment was conducted to evaluate the perceptual effects of the generated fonts. As illustrated in Fig. 8, a paragraph was printed on A4-sized paper using six different fonts "BiauKai," "HanziPen," "Lingwei," "nanTai" with contextual alternatives, "nanTai" without contextual alternatives, and a real handwriting sample. “BiauKai,” “HanziPen,” and “Lingwei” represent a range of computer fonts, from standard typewriter-style to mimicking human handwriting style. To further investigate whether the variation of the same characters enhances the perception of human handwriting, two paragraphs were printed using the “nanTai” font, one with and one without the contextual alternatives. Additionally, a real handwriting sample, written by the same person who created the “nanTai” font, was included as a baseline condition.

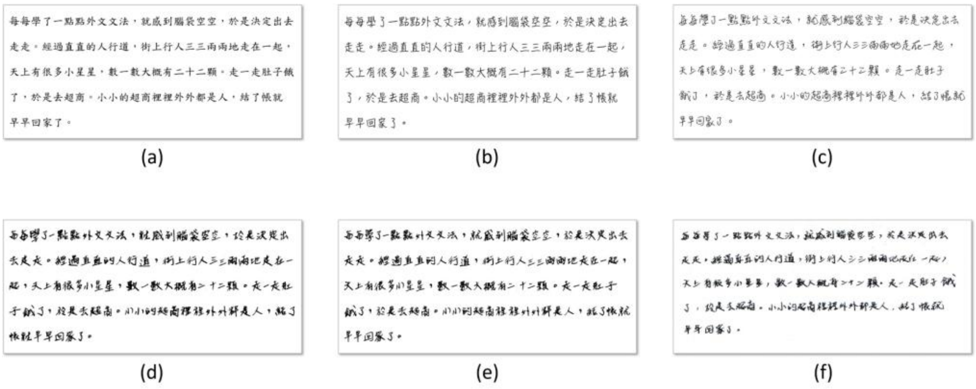

Fig. 8: The same paragraph printed with the following fonts: (a) BiauKai; (b) HanziPen; (c) Lingwei; (d) writesTai without variation; (e) writesTai with variation; and (f) actual handwriting.

The experiment contained two evaluation methods: a ten-point preference rating scale and a forced-choice preference assessment. In the preference rating task, participants read each printout and rated how closely it resembled real handwriting on a scale from 1 to 10. In the forced-choice preference assessment, participants were presented with pairs of printouts and asked to select the one that most resembled real handwriting. The total number of selections for each printout was used to establish a preference order. Twenty participants took part in the study, each rating the presented printouts twice and making a forced-choice selection for each pair twice.

Tab. 1 presents the results of the preference ratings and total selections for each printout of the forced-choice preference assessment. The data indicate that real handwriting was the most preferred, followed by the version printed with "nanTai" contextual alternatives enabled, and then the version with contextual alternatives disabled. In contrast, the typewriter-style font “BiauKai” received the lowest rating, followed by the computer-simulated handwritten fonts “Hanzipen” and “Lingwei.”

The preference ratings closely aligned with the forced-choice preference assessment, as the total number of preferred selections for each printout followed the same ranking. Real handwriting received the highest number of preferred picks (166), followed by "nanTai" with contextual alternatives enabled (157). Statistical analysis confirmed that the differences in preference ratings were significant ($H = 91.265$, $p < .005$), with post hoc analysis indicating that all pairwise comparisons were significant, except between real handwriting and "nanTai" with contextual alternatives enabled. This finding suggests that our newly developed fonts, which incorporate actual handwritten characters and display different variations side by side, can be perceived as authentic as real handwriting.

	BiauKai	*HanziPen*	*Lingwei*	*nanTai with Variation*	*nanTai without Variation*	*Actual writing*
Rating	1.00	2.80	5.13	7.88	7.20	8.00
Total picks	0	42	107	157	128	166

Tab. 1: Comparison between preference rating and forced-choice preference assessment.

Conclusions:

This paper presents a working prototype for creating a personalized handwriting font that captures the natural inconsistencies found in human handwriting. The variation of the same character enhances the font's authenticity, making it appear more organic and less mechanical. This approach brings more emotion to digital communication, rekindling the heartfelt sentiment of handwritten letters.

Although this paper primarily focuses on Traditional Chinese characters, the proposed prototype is adaptable to accommodate characters from various languages. This is because the font is encoded in Unicode BMP, ensuring compatibility with characters from different scripts. Furthermore, the font file can be reencoded in Unicode Full without disrupting the font-creation process, thereby providing support for all Unicode-encoded characters.

References:

[1] E. Glikson, A. Cheshin, and G. A. van Kleef, “The Dark Side of a Smiley: Effects of Smiling Emoticons on Virtual First Impressions,” Soc. Psychol. Personal. Sci., vol. 9, no. 5, pp. 614–625, Jul. 2018, https://doi.org/10.1177/1948550617720269

[2] J.-W. Lin, F.-S. Lin, Y.-C. Wang, J.-M. Ho, and R.-I. Chang, “FontCloud: Web Font Service for Personal Handwritten, Ancient, and Unencoded Characters,” in Future Information Technology - II, J. J. (Jong H. Park, Y. Pan, C. Kim, and Y. Yang, Eds., Dordrecht: Springer Netherlands, 2015, pp. 113–119. https://doi.org/10.1007/978-94-017-9558-6_14

[3] W. Pan, Z. Lian, R. Sun, Y. Tang, and J. Xiao, “FlexiFont: a flexible system to generate personal font libraries,” in Proceedings of the 2014 ACM symposium on Document engineering, in DocEng ’14. New York, NY, USA: Association for Computing Machinery, Sep. 2014, pp. 17–20. https://doi.org/10.1145/2644866.2644886

[4] G. Van Rossum and F. L. Drake Jr, Python tutorial, vol. 620. Centrum voor Wiskunde en Informatica Amsterdam, The Netherlands, 1995.

[5] G. Williams, “Font Creation with FontForge,” vol. 24, no. 3, 2003.

[6] Graduate Institute of Chinese of the National Taiwan Normal University, Chart of Standard Forms of Common National Characters. Ministry of Education, 1978.