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Design Research on Chinese Typeface in Screen Visualization

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Abstract: With the widespread adoption of digital screens, the design of Chinese fonts optimized for display faces unique challenges. This study aims to establish practical design guidelines to enhance the readability and visual comfort of Chinese characters on screens. First, it reviews the evolution of Chinese media, the iteration of screen technologies, and the development of display fonts. Second, it analyzes the characteristics of screens as a textual medium to derive design principles for screen-displayed Chinese characters. The study compares parameters such as the Center Section, Internal Spacing, and Stroke Width of print-based and screen-displayed Chinese characters. It proposes corresponding design recommendations for screen-displayed Chinese characters based on these parameters, providing a design paradigm for future font development in the field of human-computer interfaces.

1. Introduction

As the bedrock of the continuous development of Chinese civilization, Chinese characters have played a pivotal role throughout millennia of historical evolution, with their medium of transmission undergoing multiple iterations through successive revolutionary inventions. Against the backdrop of the digital age, as multimedia devices like smartphones and computers become ubiquitous, screens have increasingly emerged as the central conduit for displaying and receiving information, serving as a primary vehicle for textual communication. According to the findings of the 21st National Reading Survey, China's digital reading penetration rate reached 80.3% in 2023, marking a 0.2 percentage point increase from 2022. To enhance the comfort of electronic reading, the field of Chinese typeface design should prioritize screen display optimization by developing highly legible screen fonts, thereby keeping pace with the demands of the modern era.

2. Overview of Media and Display Technology Development

2.1. The Evolution of Chinese Character Media

The origins of Chinese character culture date back to ancient times. In his essay "Further Discussion on Several Theories Regarding the Origin of Chinese Characters," Yu Chao cited theories

such as the “knot-tying for record-keeping” theory, the “Eight Trigrams” theory, and the “Cang Jie invented characters” theory. The most widely accepted “primitive pictographs” theory explains that Chinese characters evolved from the creation of character forms inspired by their meanings, later acquiring specific pronunciations, thus forming a writing system[1].

Oracle bone script, the ancient writing inscribed on tortoise shells and animal bones for divination and record-keeping during the Shang Dynasty, represents the direct lineage of contemporary Chinese culture and stands as the progenitor of Chinese writing. Driven by advances in productivity, the Shang Dynasty witnessed significant developments in copper smelting and bronze casting techniques. To showcase their power and historical achievements, high-ranking officials and nobles began inscribing ritual bronze vessels. Thus, bronze replaced animal bones as the medium for Chinese characters, giving rise to the script known as “bronze inscriptions”. Compared to oracle bone script, bronze script featured more complex characters with flowing strokes and neat lines. Due to the limitations of their physical media, oracle bone and bronze scripts could not be widely disseminated. During the Spring and Autumn and Warring States periods, bamboo slips emerged as a new medium for spreading written language, reaching its peak during the Qin and Han dynasties. After Emperor Qin Shi Huang unified the six states, he implemented a standardized writing system, making bamboo slips the universally accepted medium for writing across the nation. During this period, bamboo slip production techniques advanced significantly. Specialized writing standards and systems emerged, and bamboo slips were systematically woven into “jian du” (bamboo books), the earliest form of books in China. By the Western Han Dynasty, people had mastered papermaking techniques. During the Eastern Han Dynasty, Cai Lun refined these methods based on prior knowledge, significantly improving paper quality while reducing costs. Paper thus became the most widely used writing material to date, making a foundational contribution to the dissemination of classical texts.

2.2. The Development of Display Technology

Today, with the widespread adoption of multimedia devices like smartphones and computers, screens have increasingly become the primary medium for conveying textual information, serving as the central hub for information display and reception. Different screen types significantly impact readers’ perception of on-screen fonts. Current screen display technologies are categorized into four types based on their technical principles: CRT (Cathode Ray Tube), LCD (Liquid Crystal Display), LED (Light-Emitting Diode), and OLED (Organic Light-Emitting Diode)[2]. CRT monitors display images through high-speed electrons emitted from an electron gun that strike red, green, and blue pixels on the screen, causing phosphors to emit light[3]. LCDs operate by applying voltage to conductive plates between two electrodes, altering the arrangement of liquid crystal molecules to regulate light transmittance and control screen imagery. Their lightweight, portable and space-saving design enables mobile display applications. LED displays assemble graphics using flat modules of light-emitting diodes, offering vivid colors and strong three-dimensional effects. They are commonly used in public spaces such as stations, hospitals, and shopping malls. OLED displays possess self-emissive properties. Leveraging advantages such as simple manufacturing processes and flexibility, they are widely adopted in mobile electronic devices, such as smartphones and tablets. However, challenges remain, including short lifespan and difficulties in achieving large screen sizes.

3. Display Font Technology

3.1. Font Library

As screen display technologies diversify, while each carries inherent drawbacks, various font libraries tailored for screen media have emerged. Font libraries are collections of text stored in

encoded formats, primarily in two types: bitmap fonts and vector fonts[4]. Bitmap fonts consist of characters formed by groups of pixels, resulting in jagged edges when enlarged. This format originates from the Bresenham line algorithm[5], developed in the 1960s by Jack Bresenham, then a senior technical staff member at IBM. This algorithm plots discrete points to draw straight lines and curves on a pixel array at specified coordinates. This algorithm determines optimal solutions based on a pixel grid coordinate system, establishing the fundamental principle for pixel-based rendering in computer graphics and serving as the theoretical foundation for on-screen text display. In contrast, vector fonts are defined by curves connecting multiple nodes. Rendering engines interpret these vector parameters to display the font, enabling infinite scaling without jagged edges.

3.2. Font Display Technology

The display quality of screen fonts is influenced by multiple factors. To achieve consistent visual effects across different real-world conditions, a font requires the support of various font display technologies.

Anti-aliasing: Using vector scaling algorithms, this technique generates pixels with varying grayscale values between enlarged jagged edges, creating visually smooth contours [6]. Hinting: Optimizes small-font display by removing unnecessary strokes or merging adjacent horizontal strokes based on visual recognition needs, while providing adequate white space to enhance readability. Embedded bitmap technology: Embeds specialized bitmap fonts within a font family for small-size display, reducing computational load on computers. ClearType: Enhances display precision by replacing each pixel with finer RGB subpixels, delivering more refined text rendering.

4. Characteristics of the Screen as a Textual Medium

4.1. Image composed of pixels

Screen media differ from print media in how they are displayed. Pixels are the smallest units used by electronic screens to display images, and font images on screens are likewise composed of pixels[7]. This necessitates that fonts displayed on screens be legible and adaptable across multiple screen resolutions. Even when displayed in small font sizes where complete details cannot be rendered, they must convey the font's characteristics to achieve recognizability.

4.2. Self-luminous

The self-illuminating nature of screen media enhances reading in dark environments, but the inevitable optical osmosis reduces the legibility of on-screen fonts. Optical osmosis refers to the outward expansion of white or light-colored objects against black or dark backgrounds. For instance, a white circle on a black background visually expands into a hexagon at a certain viewing distance, while a black circle on a white background contracts into a triangle [8]. Similarly, when reading dark text on a light background on screen, the background's optical osmosis erodes the finer strokes of the font, causing the character shapes to contract and reducing legibility visually.

4.3. Hypertext

Traditional print media, constrained by physical page space, offer readers limited information. In contrast, the hypertext nature of screen-based media allows readers to jump between interfaces at any time to access comprehensive content. Moreover, the inherently memory-enabled browsing interface eliminates the need to search for browsing history after closing a physical book. Take articles on

WeChat Official Accounts as an example: when referencing a previously discussed topic, links to past articles are often included in the text, allowing new readers to catch up. This hypertextual nature of the medium empowers readers to personalize their reading experience by freely navigating through textual content.

5. Attempts at Displaying Chinese Fonts on Screens

5.1. Sans-serif

5.1.1. Microsoft YaHei

To address the issue of poor visibility for small fonts on low-resolution screens, Microsoft Windows Vista released the first ClearType-enabled Chinese display font—Microsoft Yahei—in December 2006[9]. This sans-serif font features slightly flattened square shapes and extended strokes, providing clear visual clarity for screen reading. However, it suffers from an inherent flaw: its disproportionately full character width makes individual characters appear overly large and heavy. Additionally, its excessively tight character spacing results in high grayscale in body text, creating a visually oppressive effect on readers. Nevertheless, Microsoft YaHei undeniably represents a milestone in the design of Chinese screen fonts.

5.1.2. Founder YouHei

Founder YouHei, as a new generation of Chinese font for screen displays, embodies the design philosophy of "making text more approachable and reading more comfortable" [9]. While tightening the central area, Founder YouHei addresses the excessive character area ratio seen in Microsoft YaHei by reducing the character area and increasing character spacing. This creates sufficient white space when text appears in paragraphs, thereby adjusting the gray scale. It alleviates the psychological pressure caused by excessive gray scale, extending reading time. For stroke details, Founder YouHei adopts simpler stroke combinations. Additionally, it incorporates traditional calligraphic characteristics into its stroke design, reflecting the artistic principles of starting, connecting, turning, and ending.

5.2. Serif

5.2.1. Source Han Serif CN for Display

Source Han Serif CN for Display is a font optimized for screen display based on standard Songti typefaces. Beyond clearly distinguishing horizontal and vertical strokes to achieve thin horizontal and thick vertical lines, it retains the serif elements characteristic of paper-based Songti designs. However, its drawbacks include a flattened, square overall shape and excessive weight, which cause characters with numerous horizontal strokes to exhibit inconsistent gray levels and reduced legibility within paragraphs.

5.2.2. Founder YouSong

Founder YouSong is a typeface that incorporates serif characteristics into the structural framework of Founder YouHei. Before its emergence, display text was dominated by sans-serif [10]. In balancing the thickness of horizontal and vertical strokes, it draws on sans-serif characteristics to achieve uniform thickness in both directions. It also employs serifs—a hallmark of serifs—with restraint, deliberately toning down the typical Song features. To better adapt to pixel-based display effects,

Founder YouSong reimagines the traditional serif characteristics at stroke transitions. Complex shapes are uniformly transformed into triangular forms, which not only align with pixel-based imaging but also serve as invisible visual guides, thereby accelerating reading efficiency. To mitigate optical osmosis, Founder YouSong slightly enlarges the inner space of characters and appropriately separates connected strokes.

6. Conclusion

6.1. Appropriately Enlarge the Center Section

Comparing Helvetica and Didot at the same size reveals that Helvetica appears visually larger. This is due to its greater x-height. In English type design, the height from the baseline to the top of the lowercase letter x is termed the x-height, which directly impacts the legibility of screen fonts. Inspired by this, when analyzing different Chinese fonts, the size of the center section directly impacts legibility. Within a specific range, legibility is proportional to the size of the center section. For example, comparing Heiti and Microsoft YaHei, the latter uses a larger center section, resulting in higher legibility on screen. This contrast becomes more pronounced at smaller font sizes. Therefore, the principle of enlarging the center section within the range of easy recognition should be more widely applied in the design of Chinese fonts for screen display.

6.2. Adjust the Internal Spacing of the Font

Due to the pixel-based imaging characteristics of screen media, stroke adhesion inevitably occurs at small font sizes, reducing legibility and affecting the readability of paragraph text. To address this issue, screen-display Chinese character design should adjust internal spacing within the font—specifically, minimizing stroke adhesion without compromising text recognition. For instance, Songti fonts represent a relatively traditional serif style, meticulously adhering to calligraphic characteristics—particularly evident in the merging of vertical and horizontal strokes. Founder YouSong was deliberately designed to separate these merging strokes within the bounds of legibility, thereby preventing such merging and enhancing both character recognition and paragraph readability.

6.3. Adjust Stroke Width

The self-illuminating nature of screen media causes optical osmosis. Under its influence, when reading dark text on a light background, the background light erodes the finer strokes of the characters, impairing the reading experience. Therefore, during font design, it is essential to consider how text appears on screen media and make localized thickness adjustments to strokes susceptible to optical osmosis. Songti, characterized by a pronounced distinction between horizontal and vertical strokes, is more susceptible to optical osmosis. Comparing Songti with Founder YouSong shows that the latter incorporates serif-like features, resulting in less pronounced stroke contrast. Consequently, Founder YouSong is more suitable for screen display than standard Songti.

Disclosure Statement

The author declares no conflict of interest.

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