User's Individual Needs Oriented Parametric Design Method of Chinese Fonts

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Abstract. The rapid development of technology and the changes in reading ways have promoted the research related to Chinese characters, while the new patterns of information acquisition, dissemination and communication based on modern internet technology have posed requirements for individualized design of Chinese characters. In this paper, for providing a new rational and personalized design method for Chinese characters, 3 kinds of parameters as shape parameters, structure parameters and effect parameters of Chinese characters are defined. A database of common characters, stored in the cloud and developed in a Crowdfunding way, is designed for providing design elements. Parametric Design System and the relevant application prototype is established, which is based on the rule of form and structure of Chinese characters, and the analysis of application interface characteristics. Then, the parametric design of Chinese characters can mark the information dissemination with a personal imprint in the context of modern technology and culture.

Keywords: Chinese character · Strokes · Structure · Parameter · Design

1 Preface

Mobile internet entered into our daily life at the beginning of the twenty-first century. People's reading ways have changed significantly that electronic reading now dominates. The emergence of various social networks, including but not limited to Facebook, Twitter, WeChat and QQ, influenced most people's social networking patterns. Fundamental changes have taken place in information communication. While technology revolution brings us convenience in information communication, it also, to some extent, eliminates the personality traits in communication and results in fast-food style affective interaction. Joy brought by one simple handwriting letter is now nowhere to be found. In the process that the carrier of text changes from visible to invisible, it is worthwhile for us to endeavor to retain the personal, emotional and aesthetic value of characters.

Although the transmission ways of culture around the world are still diverse today, development of the technology of communication and transportation has brought substantive changes in the scale and speed of culture transmission. Resource sharing has become one of the themes of social development. Collaboration and teamwork have become the inevitable trend of development. In such circumstances, the character,

as a basic carrier of cultural transmission and communication, is playing an increasingly important role. Furthermore, from the perspective of cultural inheritance and development, design and research related to characters is indispensable.

2 Design of Chinese Characters

2.1 Attributes

Characters mainly have three aspects of properties: (1) They are visible and readable. Characters concrete the voice in the form of visual symbols. (2) They serve as carrier of culture inheritance and communication. Characters can break the constraints of time and space, record knowledge and convey thought. (3) They can be redesigned. Since characters are visual symbols created by human, they can be redesigned if necessary. The design of forms should be based on the requirements in application.

2.2 The Evolution of Chinese Characters

China is one of the oldest civilized countries in the world. As an important part of Chinese civilization, Chinese characters originated in hieroglyphs and have a history of more than 3300 years. In this history, Chinese characters evolved through several different handwriting font types, including Jinwen (inscriptions on ancient bronze objects), Zhuanshu (seal character), Lishu (official script), Kaishu (regular script), Xingshu (running script) and Caoshu (cursive script) [1]. After the application of printing technology, a variety of printing fonts, including Song and boldface, are widely used in books, newspapers, magazines and all kinds of electronic media. Evolution of Chinese characters is a modeling process (Fig. 1).

Fig. 1. The development of Chinese characters and the transformation of attributes

2.3 Design Method of Chinese Characters

Because design of Chinese characters is one of the important means to transmit Han culture, abundant design products have been achieved and applied in this field. Chinese characters have the attributes of both the graphics and text. Existing relevant research mainly focuses on the graphic attributes of Chinese characters. However, Germany Sinologist Lothar Ledderose proposed a modular system of Chinese characters in his book Ten Thousand Things: Module and Mass Production in Chinese Art, by which the Chinese characters are divided into several parts and can be reconstructed [2]. This is a thinking way of design that treats the Chinese art and social culture from the formal logic perspective.

Generally, the design work on Chinese characters can be categorized into font design and graphic design.

Font Design of Chinese Characters. With the development of technology, computers are increasingly applied in font design. Currently, there are more than a dozen common used computer font types and tens if not hundreds of fonts in each type. In font design, professional designers complete the design of a set of characters systematically on the basis of certain features of structure or shape of Chinese characters. The design cycle is long, and each character of the same font must be unified in details. Typical design procedures are as follows: (1) a new font is designed by processing and reformatting a basic font such as Song or boldface. (2) a handwritten font with individual features can be designed through handwriting, scanning and redesigning.

Graphic Design of Characters. In graphic design, designers creatively make changes in the structure, color and/or texture of a single or several Chinese characters on the basis of the characteristics of the characters to get a good visual effect. This process endows the characters with profound meaning and it is widely used in the design of logo, poster, packaging, etc.

2.4   Requirements of Chinese Characters Design in the Context of Modern Society and Technology

Psychological Mechanism of Font Users: Today, the main application way of the characters has turned to information transmission based on digital technology. Because the word to express emotion can be copied easily now, the communication way with personal imprinting becomes precious.

New Requirements in Design by Evolution of Recording Function: Chinese characters are symbols used in writing and expression. They should be able to fully reflect the content and accurately convey information (Bin ZHAO, 1993) [3]. When social interaction based on internet or even on mobile internet becomes an important part of social life, QQ and WeChat are filled with new vocabulary, the recording function of Chinese characters altered accordingly. The influence of this alternation manifests as the creation of new characters or new usage of existing characters through processes including using varied characters, changing or increasing strokes of characters, recreating characters, etc.

Protection and Inheritance of Cultural Resources: In the long history of Chinese civilization, a large amount of character design resources has been accumulated. Taking advantage of these cultural resources to complete the recreation of Chinese character culture, we can see new requirements and have new perspectives in the study and design of Chinese characters.

3   Parametric Design Method of Chinese Characters

According to the statistics of Chinese Characters National Standard (GB2312-1980), primary and secondary library contain 6763 characters [4]. Along with the changes of cultural context, Chinese characters have evolved gradually from original hieroglyphic to abstract symbols, which are constructed by points and lines cutting a rectangular space. Chinese characters of the same font are graphic symbols with similar dimension and style.

3.1   Deconstruction & Structure Analysis of Characteristics

Analysis of Characteristics. Chinese characters can be deconstructed into four levels, including character, component, stroke and detail drawing (stroke with a specific shape).

Table 1. Structure of Chinese characters and definition of parameters (秋as an example)

Structure level		Sample	Parameters	Contents
Character		秋	EPs (effect parameters)	Overall effect (including silhouette, proportions, etc.)
Compo-nents	Structural style	禾 火	StPs (structural parameters)	Structural style (left vs. right)
	Parts			Relationships between strokes, node information, etc.
Strokes		一一丨八丶丿八	ShPs (shape parameters)	Basic shape and proportion of strokes
Drawings		秋		

Types of Chinese Character Structure. According to number of components, Chinese characters can be divided into two classes as simple characters (Table 2) and

Table 2. Structural features of simple characters

Features	Samples	Features	Samples
Symmetric	田、中	Well-proportioned	三、川、王
Balanceable	天、大、人	Changed appropriately	日、目、曰

compound characters (Table 3: according to the relationships among components, they can be divided into 12 types).

Table 3. Tactic forms of compound characters

No.	Structural relationship	Samples	No.	Structural relationship	Samples
a	⊞(left vs. right)	挣、伟	g	⊞(Right down surround)	建、连
b	⊟(upper vs. down)	志、苗	h	⊞(Upper 3 sides surround)	同、问
c	⊞(left, middle & right)	湖、脚	i	⊞(Lower 3 sides surround)	击、凶
d	⊟(upper, middle & down)	奚、髻	j	⊟(Left 3 sides surround)	区、巨
e	⊡(upper right surround)	句、可	k	⊡(Completely surround)	囚、团
f	⊡(upper left surround)	庙、病	l	⊡(Mosaic structure)	坐、爽

All the Chinese characters can be categorized into the types above.

3.2 Shape Parameters

According to the hierarchical relationships of structure, a series of ShPs (shape parameters) can be defined to describe the shape of strokes. There are 31 types of common stroke of Chinese characters (shown in Table 4).

Classification of Strokes. Strokes are the basic units of Chinese characters. The same strokes can have different shapes due to differences in length, angle and bending form (for instance, in Table 1, there are three different shapes of PIE (" 丿 ")). Different strokes have different number and mode of ShPs. Strokes can be categorized according to these principles as follows: (1) There are 6 kinds of single basic strokes, including dot (DIAN), horizontal stroke (HENG), vertical stroke (SHU), left-falling stroke (PIE), right-falling stroke (NA) and rising stroke (TI). (2) Compound strokes are classified according to the first stroke. (3) Compound strokes with a *bending* drawing are relatively complex, so they are categorized into a special type.

Therefore, a classification of strokes is established (Table 5). According to this classification, we can determine the code of each stroke. For instance, the code of PIE (" 丿 ") is *"31"*. This code can be applied in the subsequent design processes.

Spline Curves Introduced to Describe the Bending Shape of Strokes. In order to accurately describe the strokes with a bending drawing, we introduce B-spline curve (NURBS). B-spline curve is defined by some given control points and related knot vectors. Spline curves pass through ordered data points and have continuities of first and second derivatives at these points. This feature allows spline curves to well describe the curve feature of strokes of Chinese characters, and provide space for adjustments of the drawing (Fig. 2a).

Definition of Shape Parameter. ShPs are defined according to the classification of strokes:

Table 4. Strokes name of Chinese character

No.	Stroke	Ex.	No.	Stroke	Ex.	No.	Stroke	Ex.
❶	一	一	⓫	㇀	买	㉑	)	豚
❷	丨	卜	⓬	㇄	儿	㉒	㇈	九
❸	丿	八	⓭	㇁	去	㉓	㇌	四
❹	丶	八	⓮	㇊	以	㉔	㇡	没
❺	、	主	⓯	㇗	山	㉕	㇋	仍
❻	乛	口	⓰	㇟	女	㉖	㇈	风
❼	㇀	地	⓱	㇄	写	㉗	㇉	及
❽	乛	周	⓲	乀	戈	㉘	㇋	专
❾	亅	小	⓳	㇉	那	㉙	㇗	鼎
❿	㇆	水	⓴	㇀	课	㉚	㇡	凹
						㉛	乛	凸

Table 5 Stroke classification & codes

	1	2	3	4	5	6	7	8	9
1 横	一	㇀	㇆	㇇	㇏	㇕	㇗	㇉	㇇
2 竖	丨	㇂	亅	㇄	㇙	㇊	㇐	㇢	
3 撇	丿	㇀	㇁						
4 捺	丶								
5 点	、								
6 提	一								
7 弯	乀	㇗	乇	)	㇈	㇡	㇋	㇌	

The ShPs of single basic strokes including dot (DIAN), horizontal stroke (HENG), vertical stroke (SHU) and rising stroke (TI) are the coordinates of both ends. Because the left-falling stroke (PIE) and right-falling stroke (NA) are curve, the relevant ShPs include a group of control points besides both ends.

All composite strokes can be constructed by basic strokes according to the strokes' classification in Table 5. Therefore, ShPs includes the coordinates of 3 kinds of points: (1) both ends and middle point of stroke, (2) turning points, (3) and data points of Spline curve (Fig. 2b). Controlling and adjusting the positions of these 3 kinds of points, we can change the shape of strokes effectively. While the code of stroke is known, the number of ShPs required is determined.
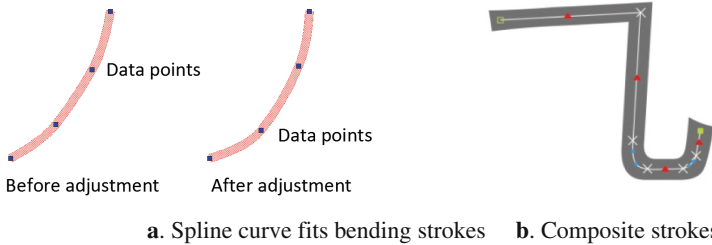

Data points

Before adjustment   After adjustment

Data points

a. Spline curve fits bending strokes   **b**. Composite strokes

Fig. 2. a. Spline curve fits bending strokes **b**. Composite strokes

3.3 Structural Parameters

According to the analysis of Chinese characters structure above, StPs (structural parameters) can be defined to describe the composition of components and the construction relationships of the strokes.

First Structural Problem: Type and Structural Form. Chinese characters can be categorized into simple characters and compound characters. The structural features of

simple characters are totally decided by the relationships among strokes. There are twelve types of forms of compound characters, so the structural features of compound characters depend not only on the relationships among strokes, but also on the composition of components.

We define the first type of StPs for the following aims: (1) Distinguishing different types of character (the code of simple character is *10*, and the codes of compound character are *2a, ...,2 l*, shown in Table 3). (2) Adjusting (moving, rotating or scaling) the positions and dimensions of components if the character is a compound character (Fig. 3 shows different fonts created by modifying StPs).

Fig. 3.   Different fonts created by modifying StPs

Second Structural Problem: Stroke Construction. There are only two types of relationships between strokes: intersect or non-intersect. (For instance, in the character 秋 in Table 1, HENG intersects with SHU, but DIAN does not intersect with any strokes) Therefore, the relationship between strokes can be described by whether the intersection exists. The second StPs should include: (1) The number of strokes in relevant character or component (i.e. the total number of strokes for a simple character, and the number of stroke in relevant component for compound character); (2) Whether the intersection exists and the relevant position of strokes to determine the relationships among strokes. By moving, rotating and scaling strokes, the structure relationship can be adjusted. (3) Dimension proportion between strokes.

Study on the Thresholds of StPs to Ensure Cognition of Characters. Chinese characters shall be designed and the structure shall be adjusted on the premise that the characters can be cognized. Some characters are composed by same strokes but have completely different meanings because of the differences in structure parameters. To figure out the thresholds on StPs, we conducted a cognition experiment by adjusting the StPs of 4 groups of typical characters. Sixty volunteers participated in this experiment. Experimental data is shown in Table 6.

Through the cognition experiment, we have three findings: (1) Thresholds on StPs definitely exist. If the StPs are beyond the allowed range, the cognizability of the character will be compromised. (2) Different characters require StPs with different thresholds. (3) The operating context (font size and characters around the experimental character) will have certain influence on the cognizability.

3.4   Effect Parameters

EPs are defined mainly to control the basic characteristics of Chinese characters. The traditional outline of Chinese characters is rectangle. By stretching, flattening, leaning

or changing the outline into rounded rectangle or trapezoid, we can have different character designs. Furthermore, although this method is based on boldface font, we can still change the thickness and other details of strokes to achieve personalized design of characters (Fig. 4).

Table 6 Recognition experiment of Chinese character

Test sample1		土	土	土	土	土	土	土
Ratio 1		−15%	−10%	−5%	0	5%	10%	15%
tǔ 土	1	2	1	3	29	55	58	57
	2	0	1	2	20	57	60	59
shì 士	1	58	59	57	31	5	2	3
	2	60	59	58	40	3	0	1
Test sample2		日	日	日	日	日	日	日
Ratio 1		−30%	−20%	−10%	0	10%	20%	30%
rì 日	1	57	56	51	39	0	0	0
	2	51	56	52	35	5	0	1
yuē 曰	1	3	4	9	21	60	60	60
	2	9	4	8	25	55	60	59
Test sample3		由	由	由	由	申	申	申
Ratio 3		0	5%	10%	15%	20%	25%	30%
yóu 由	1	60	45	34	11	2	0	0
	2	60	51	42	15	2	0	1
shēn 申	1	0	15	26	49	58	60	60
	2	0	9	18	45	58	60	59
Test sample4		人	人	人	人	入	入	入
Degree 4		-15	-10	-5	0	+5	+10	+15
rén 人	1	57	56	59	60	17	0	2
	2	60	60	60	59	8	0	0
rù 入	1	3	4	1	0	43	60	58
	2	0	0	0	1	52	60	60

Notes: (1) Ratio 1 means the length proportion between two parallel lines.
   (2) Ratio 2 = (Length-Width)/Height
   (3) Ratio 3 describes the states of extension of the middle vertical line.
   (4) Degree 4 is the skew degree of left/right stroke.
   (5) Two different size samples are used for Recognition Test; the bigger is used in text 1.

Fig. 4. Characters designed by adjusting Eps

3.5 Technical Solutions to Parametric Design of Chinese Characters

Reference Frame for Parametric Design of Chinese Characters. A reference frame (500*500px, with addible structure lines for design) is established to provide a base, which can be used for determining the positions of strokes and adjusting the forms of strokes and characters (Fig. 5). When the design work on strokes' shape and relevant structure is finished, the comprehensive sketch of character can be achieved by adjusting the shape and proportion of this reference frame.
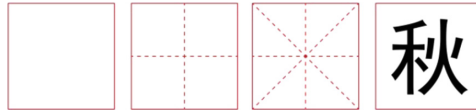

Fig. 5. Reference frame for parametric design

Database System for Parametric Design of Chinese Characters. To parameterize Chinese characters, we need to parameterize and store the relative position and proportional relationship of strokes and components, as well as the shape of strokes. As has been analyzed above, the shape of strokes can be expressed through three types of data points. However, the expression and storage of characters and components is really complex because that there are thousands of different Chinese characters. Therefore, database system should be established, which includes: (1) a database of ShPs (the code of strokes and relevant number, and positions of three types data points); (2) a database of common characters stored in the cloud with open data structure for expansion and data sharing, a database that can provide design elements with two kinds of StPs; (3) and a customized database to store personalized fonts and application.

The data accumulation of second database for design can be achieved in two ways: (1) The basic data of common Chinese characters can be input when the database is established; (2) The database can be expanded through *Crowfunding*, i.e. allowing people not limited to professional designers other than common ones design and import the data into the cloud database. Chinese characters have a history of thousands years. Chinese people know the shape of strokes and the structure of characters well. This is the cultural foundation of the *Crowdfunding* database.

Application Program for Parametric Design of Chinese Characters. Based on the boldface, the parametric design application program of Chinese font (PDAPCF) can be constructed by three different function modules: (1) new character forming;

(2) character design; (3) and information input (Fig. 6). Storing operation can be related to the basic database or customized database. Users can choose to save into two databases or not.
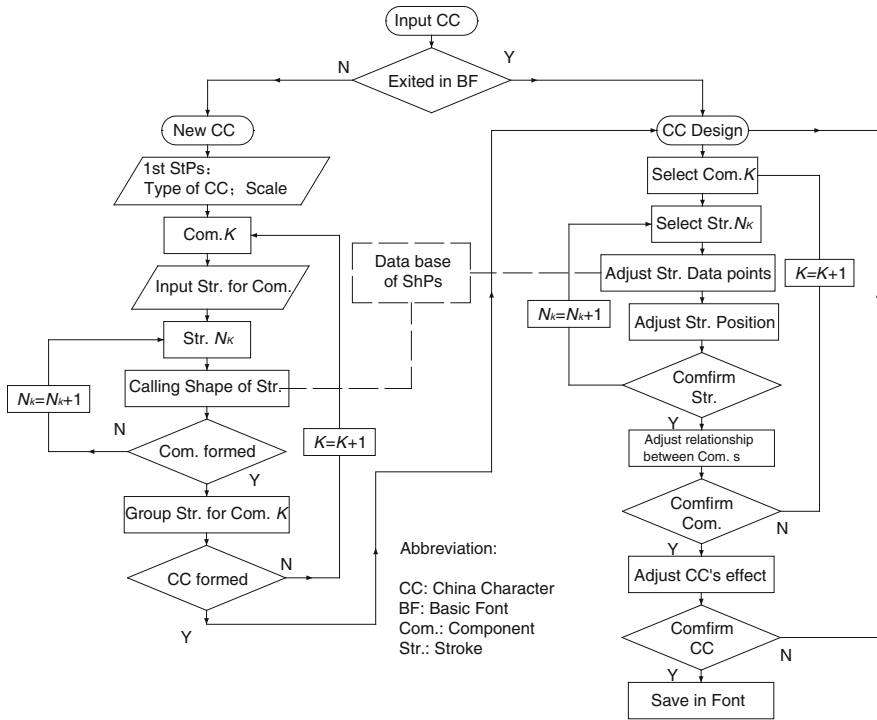

Fig. 6. Parametric design process of Chinese characters

3.6   Analysis of Interaction Characteristics of PDAPCF

This paper aims to provide common users with technical solutions to personalized Chinese characters design and related application. Therefore, the PDAPCF should have the following properties: (1) It ensures the regularity of structure and the cognizability of characters; (2) It lays emphasis on the interactive features and provides user-friendly operating experience; (3) It offers the convenience and efficiency of sharing font designs through cloud database given the users' willingness; (4) It emphasizes the interestingness of the design process and provides users with an opportunity to show personality and aesthetic orientation through the design results.

3.7   Prototype of PDAPCF

According to the foregoing analysis of technical solutions and interactive features of related application program, we can confirm that the basic application interface should include the following function partitions (Fig. 7):
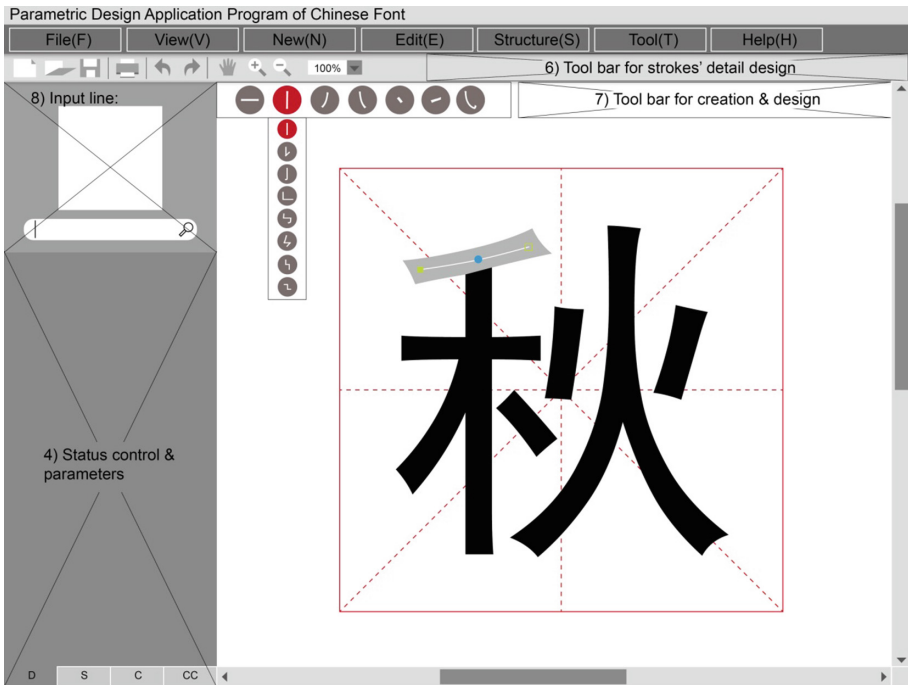

Fig. 7. Prototype of PDAPCF

1. **Command set**: dropdown menu adopted for defining and classifying all the operation command.
2. **Standard icon bar**: including common used window's operation commands; display control commands such as *Zoom* and *Pan*; and *Group* or *Explode*; etc.
3. **Design space**: providing design reference frame and addible structural lines; highlighting the data points or structural features according to the design status related to character, component and stroke.
4. **Status control icon bar**: implementing the switching operation between drawing, stroke, component and the whole character.
5. **Grouped list of strokes**: providing basic elements for new character forming (each stroke with a special code as is shown in Table 5); showing the structural features in design space (based on the database of ShPs, highlighting and applying the data points of stroke according to the relevant code).

6. **Tool bar for strokes' detail design**: providing stroke thickness adjustment function; providing characterization tool for endpoints and turning points of strokes (further statements are not here because of the space limit). Considering the basic interface should be simple and convenient to use, this bar can be designed in pop-up window.

7. **Tool bar for creation & design**: including the commands as *Stretch, Enlarge, Shorten, Lessen, Move, Rotate, Copy*, etc.

8. **Input area**: inputting and displaying the character being designed.

9. **Help & information area**: providing operating hints.

4　Conclusion

New demands for the individual design of Chinese characters have risen since information acquisition, exchange and dissemination based on modern network technology, such as online reading, social networking site, e-mail and personal web page, became popular. Parametric Design System of Chinese fonts may offer a realizable method for common people to design personalized Chinese characters. The Parametric Design of Chinese characters can mark the information dissemination with a personal imprint in the context of modern technology and culture.

Design results of PDAPCF will be stored in the custom database; the mapping relationship with commonly used font and input method is established. Then the design results can be applied in all kinds of application software, such as OFFICE, CAD and social networking software. As a result, the user's personalized features can be embodied in information communication and social interaction based on internet.

This paper ignored the application of pattern recognition technology in the design of Chinese characters (although there are abundant researches on the pattern recognition of Chinese characters). The proposed research idea and relevant result of this paper is based on printing fonts and digital communication, for the purpose of making application system simple and operable. The Crowdfunding module proposed for database expansion gives this research growth potential and good interactivity. Of course, by integrating research results of Chinese character pattern recognition, it is likely to provide common users with resources for personalized font design, thereby to inherit and develop Chinese language and cultural heritage. Therefore, we should look forward to subsequent integration of pattern recognition technology and parametric design technology of Chinese characters.

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