Learning System for Japanese Kanji Calligraphy with Computerized Supervision

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Abstract

The most popular way of learning oriental calligraphy has been by practicing the calligraphy under the supervision of a human teacher, but finding a good instructor could be difficult.
Therefore, this study proposes a Kanji calligraphy learning system with computerized supervision and analyzes the learning efficiency of the system, where the supervision includes symmetries between strokes.

The main contribution of this paper was to identify and reveal the efficacy of computerized supervision in comparison to a human supervisor. The proposed system decreased the writing-error-rates of learners from 32.7% to 3.4%, whereas the traditional practice reduced the error rates from 31.0% to 6.8%. This result shows that computerized supervision is more efficient than human supervision for learning calligraphy.

Introduction

Oriental calligraphy is a visual art that represents languages and emotions using signs and symbols, which was developed and has been evolving for centuries in countries that utilize Chinese characters in their scripting system.
The Kanji calligraphy is well-known to people in many countries and has received much artistic attention throughout history.
This paper introduces a calligraphy learning system that indicates error spots specifically. It was difficult for users to understand error spots in previous systems because the written characters were evaluated in holistic ways. We introduce the present calligraphy learning system for Japanese Kanji in later sections and show experimental results to prove its efficiency.

Calligraphy Learning System Overview

Screenshots of the developed calligraphy learning system are shown in Figure 1. At the system start, a user selects a letter to learn and checks the stroke order to draw.

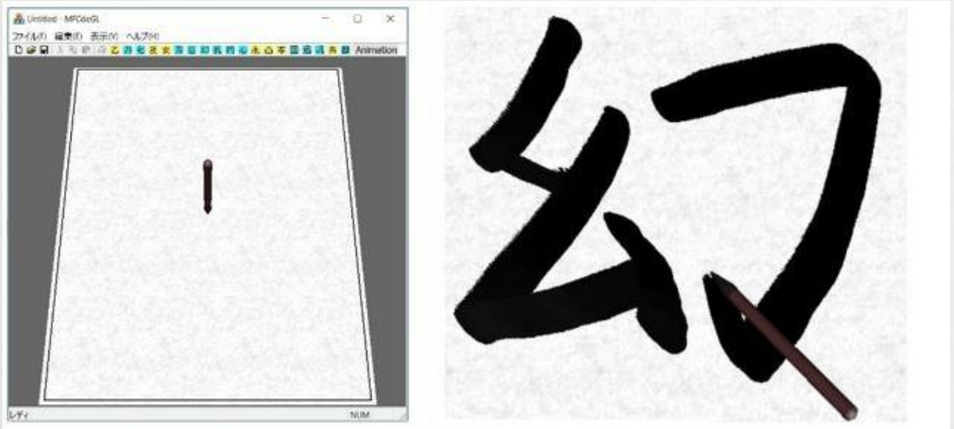

Figure 1. Main interface of the proposed system. (a) Main screen with pen and brush before writing. (b) Calligraphic character displayed during the writing process

Selection of Letters for Learning Calligraphy

An online handwritten character database (Nakamura et al. 2005) is used to cluster the strokes. This database was recorded with a pen tablet (WACOM, Japan), which includes the traces of the XY-coordinates of the pen together with the information on pressures and elevation angles at each of the data points. The characters in the database were normalized to the size of 256 × 256, and all the strokes of the characters were separated. The strokes were adjusted for their starting points to be (0, 0).

Table 1. Number of clusters after stroke clustering with different threshold values.

Threshold *	Number of Clusters
0	32,389
5	1156
6	817
7	601
8	455
9	364
10	294
11	236
12	197
13	168
14	142

Table 2. List of letters including all the stroke types possible in 2964 Kanji letters.

Character	Number of Strokes	Number of Strokes that Occurred Once in a Letter	Number of Repeated Strokes in a Letter	Number of Unique Strokes *
邸	8	7	1	3
	7	6	1	2
	6	4	2	1
迅	6	5	1	2
	6	5	1	2
写	5	4	1	3
凸	5	4	1	1
永	5	5	0	1
心	4	4	0	3
	4	3	1	1
孔	4	4	0	3
幻	4	4	0	1
日	4	3	1	3
方	4	4	0	3
女	3	3	0	1
及	3	3	0	2
七	2	2	0	1
乃	2	2	0	1
乙	1	1	0	2
Total	83	73	10	36

* The term "unique strokes" denotes that the stroke type appears in one character only.

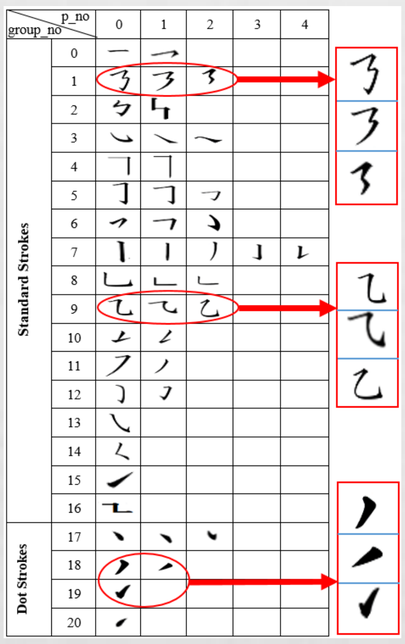

Figure 2. Forty-four stroke types in Japanese Kanji Calligraphy.

Evaluation of Calligraphy Writing

The proposed system was evaluated with 19 characters comprising the 44 types of strokes. Twenty-two Japanese people (aged 18 to 55 years, 20 males and 2 females) participated in scripting Kanji calligraphy, and the learning efficiency was evaluated in comparison to the traditional method with brush and paper. None of the participants were expertized in Japanese calligraphy.

Table 3. Features for calligraphy evaluation, categorized into 10 groups.

Evaluation category	Description	Features for evaluation
Brush pressure	Thickness of stroke at the stroke starting/end points	- Pen pressure at stroke starting/end and corner points
Fade	Gradual change of stroke width at stroke end	- Starting/end position - Direction - Smoothness
Hook	Sudden change of stroke direction in a stroke	- Starting/end position
Horizontal/ vertical stroke	Horizontal or vertical strokes without curves	- Tilting angle - Heading/sharpness at the end
Distance	Distance between strokes	- Distance between strokes
Position	Position of stroke relative to other strokes	- Relative position of strokes' starting and end points
Length	Length of stroke	- Length of strokes/segments
Angle	Angle between two strokes or segments	- Angles at between segments in a stroke - Angles between strokes
Balance	Balance of strokes and character shapes	- Ratio of stroke lengths between segments/strokes - Ranks of stroke lengths - Relative tilting angles of strokes - Ratio of height to width of a character - Horizontal/vertical position of central vertical/horizontal stroke
Other	Errors that are not categorized above	- Curvature of corners - Writing speed - Pen movements at corner (should move slightly upward)

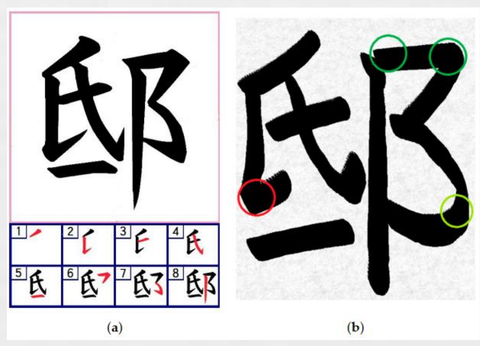

Figure 3. An example of calligraphic scripting by a novice.

Table 4. Writing issues discovered by the proposed system from the example of Figure 3.

Problem No.	Stroke No.	Issue
1	2	The angle of hook is not correct.
2	6	The 6th stroke should start at the same vertical level as the 4th stroke.
3	6	The horizontal stroke should not move upward or downward.
4	7	The corner point of the 7th stroke should be at the same horizontal level as the one of the 6th and at the same vertical level to the 2nd stroke.

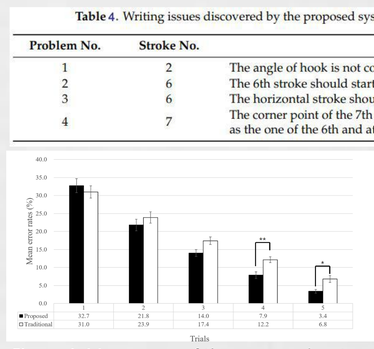

Figure 4. Mean error of the proposed system and traditional paper-based system.

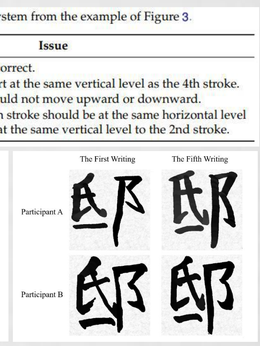

Figure 5. Example of changes in writing calligraphy

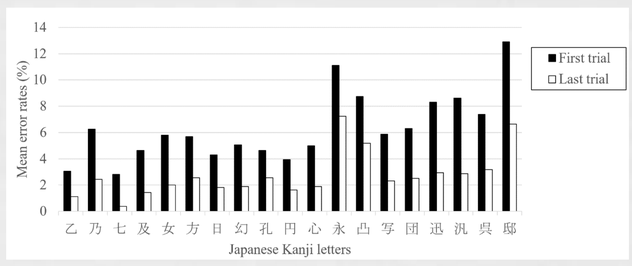

Figure 6. Changes in error rates through practice with the proposed system.

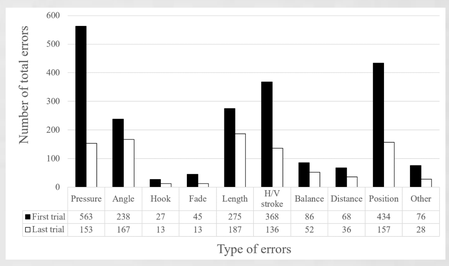

Figure 7. Changes in the total number of errors for each error type.

Conclusions

Traditional ways of learning Japanese Kanji calligraphy is writing on a paper with a brush and ink, under the supervisions of a teacher. This method has been verified throughout history; however, preparing the equipment and finding a good supervisor is not always easy depending on the circumstances.
The main contributions of this paper are as follows:

1) a calligraphy learning system that indicates errors was introduced;
2) it was proved that calligraphy learning with computerized supervision can be more efficient in reducing the number of errors than the traditional method with a human supervisor.

Although this study showed that the proposed system outperformed the human supervision regarding calligraphy teaching, this does not ensure that the proposed system is always better.
Excellent teachers may supervise the learners better, and the learners can ask calligraphy-related questions to improve their knowledge. Moreover, personal relationships between teacher and learners could not be mimicked by the proposed system.
Further, variant brush effects (e.g. dirt, blurring of characters) should be included for a better representation of virtual brush artwork.

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