An Innovative Application for Learning to Write Chinese Characters on Smartphones

Vincent Tam and Chao Huang

Department of Electrical and Electronic Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong
vtam@eee.hku.hk

Abstract. With the fast economic development in China, learning Chinese becomes very popular and significant worldwide. To most foreigners and even local students, one of the major challenges in learning Chinese is to write Chinese characters in correct stroke sequences that are considered as crucial in the Chinese culture. However, due to the potentially complex structures of Chinese characters together with their stroke sequences, there were very few available character recognition techniques that can tackle this training task well in a flexible and efficient manner. In this paper, we propose an extendible and intelligent e-learning software based on learning objects to facilitate the learning of writing Chinese characters in correct stroke sequences. Furthermore, the basic features including the evolution and pronunciation of each Chinese character can be encapsulated as part of the learning object metadata to better students' understanding. To demonstrate the feasibility of our proposal, a prototype of our proposed e-learning software was built on smartphones such that students can learn anytime and anywhere. Our proposal represents the first attempt to reduce the complexity while increasing the extendibility of the e-learning software to learn Chinese through learning objects. More importantly, it opens up numerous opportunities for further investigations.

Keywords: Chinese characters, e-learning systems, innovative applications, learning object metadata, stroke sequences.

1 Introduction

The learning of Chinese has become very crucial for both Chinese and foreigners due to the amazingly fast economic development and increasing political influence of China in the past decade. Among the four basic skills including listening, reading, speaking and writing to master any language, learning to write Chinese characters with the correct stroke sequences is often the most challenging task for foreigners, or sometimes Chinese students themselves, taking into account of the complicated structures and diversity of Chinese characters with their unique stroke sequences. Even with the latest advance in the development of intelligent character recognition techniques [5], the complexity of structures of Chinese characters together with their stroke sequences impose a serious challenge to many sophisticated e-learning software [5, 6] developed for learning to write Chinese characters. As a result, there were very

R. Kwan et al. (Eds.): ICT 2011, CCIS 177, pp. 85–95, 2011.

few available e-learning systems [1, 2] integrated with intelligent character recognition techniques to effectively handle both complex structures and correct stroke sequences of Chinese characters in a timely manner.

To reduce the complexity of the underlying knowledge domain in many practical e-learning systems, the IEEE Learning Object Metadata (LOM) standard [7] is frequently adopted to construct a systematic organization of learning objects for the specific knowledge domain. For the complex and diverse structures of Chinese characters, there are a fair number of such characters that can be decomposed into some basic constructs or sets of strokes containing specific semantic meanings, thus ideal for being represented as 'learning objects'. Accordingly, with the aid of learning object management subsystem, course or software developers can easily maintain and update the apparently complex structure of the underlying Chinese characters by breaking them down into basic sets of strokes specified as learning objects in our proposed e-learning system. Clearly, this will promote students' appreciation of the meaning of a specific Chinese character through the semantic meanings of the involved basic constructs represented as learning objects contained inside the character. Ultimately, the set of stored Chinese characters can be easily shareable with other learning content management system (LCMS) [3] that strictly follows the IEEE LOM standard. More importantly, this will help to reduce the computational complexity of the character recognition technique used in the e-learning system which can be more 'extendible' to define new Chinese characters in terms of basic sets of strokes represented as learning objects stored in its local repository.

Although the structural complexity of any Chinese character is reduced through the concept of learning objects, students may not have sufficient time to practice the writing of Chinese characters in correct stroke sequences during classes. Conventionally, web-based e-learning software [3, 5] has been developed for students to practise the writing of Chinese characters mainly on desktop computers with the Internet access. However, with the reducing prices and increasing processing speeds of mobile devices nowadays, smartphones [8] are very convenient e-learning platforms for students to practise the writing of Chinese characters at their own pace anytime and anywhere. Therefore in this project, we propose to develop an extendible and learning object based platform, namely the iWrite system, for foreigners or Chinese students to practise the writing of Chinese characters in correct stroke sequences on iPhones. Furthermore, the basic features including the evolution and pronunciation of each Chinese character can be encapsulated as part of the learning object metadata to better students' understanding.

To demonstrate the feasibility of our proposal, we implemented a prototype of the iWrite system as an extension from a previous work [10, 11] using the Objective C and the Xcode development tool for the iPod Touch™ device or iPhone. Our prototype of the iWrite system can systematically categorize all the stored Chinese characters in its database according to the predefined basic constructs as learning objects, and include Chinese characters of all the basic structures into each training exercise. In each step of the training exercise, a template of the selected Chinese character will be displayed for the students to write with their fingers in the correct stroke sequence on the touch screen. After the student finishes writing the concerned character, the iWrite system will use an efficient and heuristic-based method to check whether the stroke sequence of the inputted Chinese character is correct or not. In case the sequence of inputted strokes is incorrect, an error message will be displayed. At the end, the student will receive an evaluation report showing at which specific structure(s) of the Chinese characters that the concerned student is relatively weak. A preliminary evaluation was

conducted with some encouraging feedbacks collected. A more careful evaluation was planned around the upcoming May in which the iWrite system would be available for foreign students for trials in some selected Chinese courses in the University of Hong Kong. All in all, there are many interesting directions for further investigation including the integration of relevant multimedia or pointers to online databases about a specific Chinese character into our system, and a thorough study of the pedagogical impacts brought by our integrated system for mobile learning.

This paper is organized as follows. Section 2 reviews the basic structures of Chinese characters, some existing e-learning systems for learning to write Chinese characters, and previous works about the use of learning objects in education. Section 3 details the system design of our proposed learning object based Chinese writing system, iWrite, on iPhones to enhance learners' experience on mobile devices for learning to write Chinese, especially for foreigners. We give an empirical evaluation of our proposal on various criteria in Section 4. Lastly, we summarize our work and shed lights on future directions in Section 5.

2 Preliminaries

In the following subsections, we will review preliminaries on the basic structures of Chinese characters. Then, conventional features of existing e-learning systems that may hinder the progress of learning to write Chinese will be considered. Lastly, previous works about the possible uses of learning objects in e-learning systems will be discussed.

2.1 The Basic Structures of Chinese Characters

Chinese characters are highly structural, as totally different from the alphabetical languages such as English and Greek used in other parts of the world. Nevertheless, each Chinese character is intrinsically made up of sets/types of basic strokes as its components. There are around 30 types of basic strokes for which the following table shows the 10 common types of basic strokes.

The above types of basic strokes as components of Chinese characters totally make sense semantically and phonetically. For instance, the Chinese character for river, lake, sea and ocean are 河，湖，海，洋 respectively. It can be easily observed that all these characters share the basic component of "three dots" which is the symbol of water on the left-hand-side. Therefore, through these basic components/structure, a learner can more easily identify how various Chinese characters are related to one another, and possibly guess the meanings of new characters. Besides, in most cases, the remaining parts such as "可" and "胡" in the above examples for river and lake will also give some hints about the pronunciations of the whole Chinese characters.

2.2 Existing E-Learning Systems for Learning to Write Chinese Characters

The existing e-learning systems [5, 6] for learning to write Chinese characters can be divided into two major categories. The first category is the view-only e-learning system in which students can only see how a Chinese character should be written yet no practice is provided. For instance, the famous eStroke [6] provides the online and

offline viewing of the stroke sequences for Chinese characters. In addition to showing the stroke order of every Chinese Character, the eStroke system also translates phrases in a Chinese text passage into English or German as according to its predefined dictionary. This will greatly facilitate foreigners to understand the whole text instead of each individual character. Besides, eStroke can display the animation of the stroke sequences for both simplified and traditional variants of the same Chinese character. All in all, it can only provide guidance to students by showing how to write Chinese characters with correct stroke sequence **without any actual practice**.

Table 1. The 10 common Types of basic strokes

	Pronunciations in Pin-yin (Chinese meaning)	***Types of Basic Strokes***
1.	Heng (横)	
2.	Ti (提)	
3.	Shu (竖)	
4.	Shuzhe (竖折)	
5.	Shugou (竖钩)	
6.	Pie (撇)	
7.	Hengzhe (横折)	
8.	Henggou (横钩)	
9.	Dian (点)	
10.	Xiegou (斜钩)	

On the other hand, the second category allows the student to practise their writing and also gives some feedback to indicate if there are errors in the students' handwriting. However, there is no display or animation on how a Chinese character can be written with its correct stroke sequence for education purpose. An example is an automated Chinese handwriting error detection system [5] using the attributed relational graph matching. The system can be used to identify the stroke production errors, sequence errors and errors in spatial relationship between the strokes for a specific user's handwritten input. However, the system cannot provide useful statistics such as the average rate of errors after writing a number of Chinese characters, or a group of characters containing specific structures. Furthermore, the processing speed of the system can be slow when the characters are complicated with a lot of strokes. Therefore, in this project [10, 11, 12], we aim to design and build a more complete e-learning system with both facilities for viewing and practising the writing of Chinese characters with correct stroke sequences, and also giving reasonable performance for complex characters with a fairly large (> 13) number of strokes. Moreover, our ultimate e-learning system would provide more detailed and informative feedbacks including the aforementioned error statistic for each individual student to practise the Chinese characters with specific structures that (s)he is weak at.

2.3 Learning Objects for E-Learning Systems

A learning object is "a collection of content items, practice items, and assessment items that are combined based on a single learning objective" in an e-learning system. By following the IEEE-1484 LOM standard [7], the LOM management subsystem of the underlying e-learning system can facilitate the searching of learning objects using the standardized metadata format. Basically, LOM is used to capture explicit knowledge, context, perspectives, and opinions. Learning objects in the form of text, image or video can be imported and searched by keywords. Therefore, each user is free to access, discover and find information using the LOM. In this way, the process of learning and knowledge creation will be significantly enhanced and smoothed.

After a user uses any keyword(s) to query the LOM management system, the e-learning system can redistribute the specific query to all connected LOM repositories and then respond to the user by displaying the resulting LOM when the search is successful. For efficiency of the search, the implementation of LOM for our designated e-learning system in this work is simplified since the subjects are mainly restricted to Chinese characters and their structures. As most of the LOM search is in the form of keyword(s), the LOM management system will try to match any LOM with the provided keyword(s) at the title, description or keyword field. Accordingly, we only need to implement the corresponding search function on a relatively small subset of fields as defined in the original IEEE-1484 LOM schema, including the title, description, keyword and technical related fields.

3 Our Proposal

As considered in Section 2, most of the Chinese characters are constructed by basic structures or sets of ordered strokes that can actually be implemented as learning objects as according to the IEEE-1484 LOM schema [7]. In fact, all such basic structures/radicals have specific meanings that can be expressed as learning objects

with related keywords and linked multimedia files for pronunciation and/or animation of relevant concepts in the local repository.

Our proposed e-learning system, based on smartphones for higher portability, has implemented the concepts of learning objects since the basic strokes of Chinese characters will be implemented as learning objects with animations to promote the students' appreciation of the specific semantic meanings of the concerned basic strokes. In addition, the basic features including the evolution from the pictogram to the traditional form and also the pronunciation of each Chinese character can be easily encapsulated as part of the learning object metadata to better students' understanding. The proposed system has three main components to serve for the functions of illustration, practice, and feedbacks as clearly shown in Figure 1.

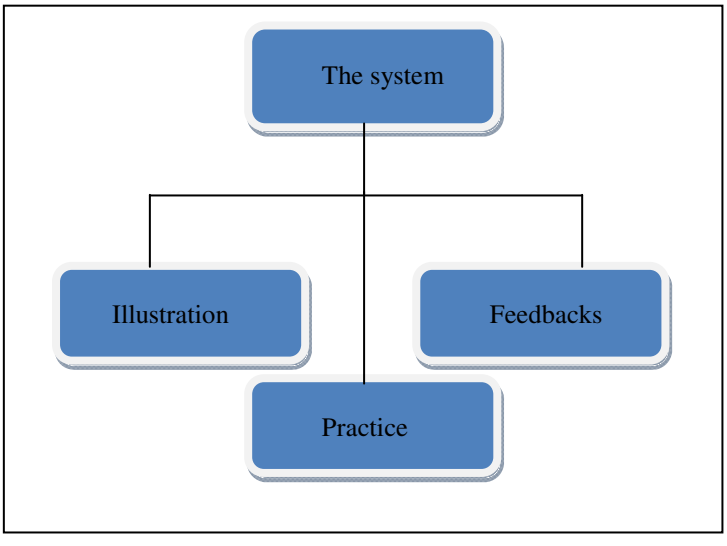

Fig. 1. The basic system architecture of our proposed e-learning system for smart-phones

For the illustration part, the e-learning system will provide motion pictures of writing Chinese characters with their correct stroke sequences. For the practice part, the system will provide Chinese character templates for students to follow in writing. The system will check the stroke sequences after (s)he finishes writing on the template. In the returned result, the system will give a detailed analysis of the student's performance including the average rate of errors over all the Chinese characters the student has practiced, and also providing suggestions via the feedbacks subsystem to each individual student on the specific structure(s) that (s)he may work hard to improve.

4 An Empirical Evaluation of Our Proposal

To demonstrate the feasibility of our proposal, we implemented a prototype of the smart e-learning platform [10, 11, 12] using the Objective-C programming language

and the Xcode Integrated Development Environment (IDE) [9] tool for execution on iPhones for its high popularity and portability. The current prototype implementation consists of approximately 2,500+ lines of source codes with 30 templates of Chinese characters for practice. It took around 4 man-months for the design and implementation of our e-learning system.

For a better evaluation, the templates of Chinese characters were built into one of the four basic structures of the underlying Chinese characters. The four basic structures include single structure, up-down compound, left-right compound and bounded structure. Table 2 shows some of the examples for each of the four basic structures.

Table 2. Examples of 4 Basic Structures of Chinese Characters Used in Our iWrite System

Structure	Examples
Single Structure	天, 上, 下, 中, 大, 甘, 日, 早
Up-down Compound	美, 金, 合, 雷, 笑, 哭
Left-right Compound	地, 和, 換, 江, 河, 明, 清, 好
Bounded structure	圓, 周, 同, 國, 回, 風

Fig. 2. The User Interface of Our iWrite System for the Template of a Chinese Character (i.e. Moon) Displayed on the iPhone Simulator

The Microsoft™ Paint program is used to build the templates of Chinese characters for our extendible e-learning system. Fig. 2 shows the graphical user interface of our iWrite system with a selected template being displayed and ready for the user to

Fig. 3. The User Interface of Our iWrite System After a User Wrote the Chinese Character (i.e. Moon) with Incorrect Stroke Sequences on the iPhone Simulator

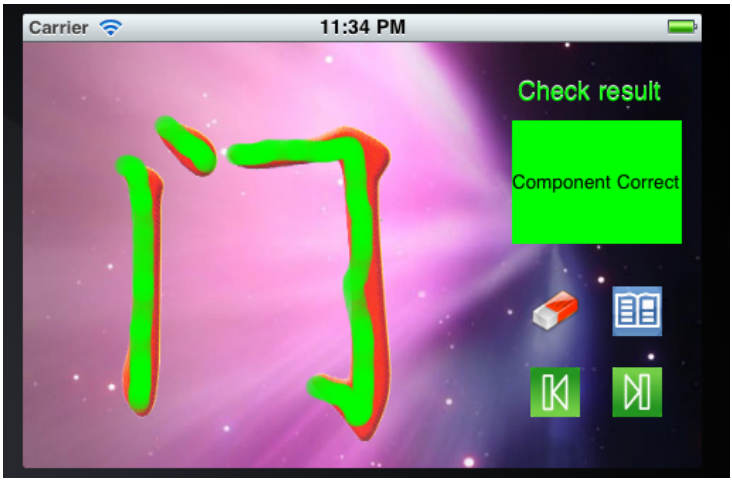

Fig. 4. The User Interface of Our iWrite System After a User Wrote the Chinese Character (i.e. Door) with Correct Stroke Sequences on the iPhone Simulator

practice on the iPhone simulator of the Xcode IDE tool. Basically, the interface of the system is divided into three parts. The left panel of the interface is the input area which will provide the template for a student to write on it. The right of the system will have two functions. The upper part is the control panel with the demonstration part being under it. On the other hand, Fig. 3 gives the user interface of our e-learning system run on the iPhone simulator of the Xcode IDE when invalid inputs for the stroke sequence are provided. Fig. 4 shows the user interface of our iWrite system when a Chinese character with the correct stroke sequences is written on the touch screen by following

the displayed template. For each stroke of the displayed template, the user's input is regarded as correct if the starting and ending points, and also direction of the user's input are consistent with those defined in the concerned stroke of the template with at least 70% of its area overlapped with that of the template. For the whole inputted character to be recognized as "correct" by our prototype, each of the inputted strokes must be correctly written in the correct stroke sequence. Furthermore, Fig. 5 illustrates the evolution of a Chinese character (i.e. horse) to better the students' understanding of

Fig. 5. The User Interface of Our iWrite System to Show the Evolution of the Chinese Character (i.e. Horse) on the iPhone Simulator

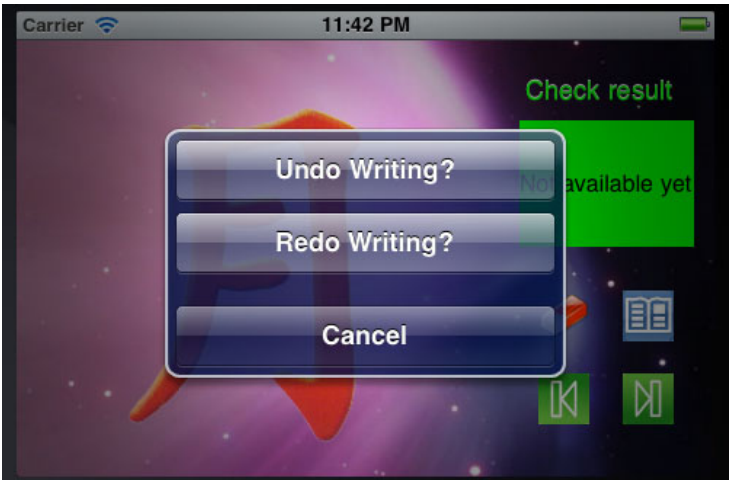

Fig. 6. The User Interface of Our iWrite System After a User Triggers the G-sensor on the iPhone Simulator to Undo/Redo the Writing of A Chinese Character

the specific meanings of basic constructs involved in this character while Fig. 6 demonstrates the unique of using the G-sensor (by shaking) on the iPhones (or smartphones) to redo or undo the writing of a Chinese character during the training process.

An evaluation plan was already formulated and would be conducted in a Chinese course offered to foreign students in the upcoming Fall Semester in the School of Chinese, the University of Hong Kong. A more detailed analysis will be performed with its result to be published by the end of that semester.

5 Concluding Remarks

In this paper, we propose to develop an adaptive and extendible e-learning platform based on the concept of learning objects for foreigners or Chinese students to practise the writing of Chinese characters in correct stroke sequences on smartphones [8]. To demonstrate the feasibility of our proposal, we implement a prototype of our e-learning system using the Objective-C and the Xcode IDE tool [9] for execution on iPhones/iPod touch. Our prototype of the targeted e-learing system can systematically categorize all the stored Chinese characters according to four basic structures, and also include Chinese characters of all the basic structures into each training session. In each step of the training session, a template of the selected Chinese character will be displayed for the students to input the correct stroke sequence using the touch-screen of iPhones. After the student finishes inputting the stroke sequences, our e-learning system will use an efficient and intelligent algorithm to check whether the stroke sequences of the inputted Chinese character are correct or not. In case the direction of any stroke or the sequence of strokes is incorrect, an error message will be displayed. At this instant, the student can click on the animation button to display the correct stroke sequence of writing the specific Chinese character through animated GIF files. At the end, the student will receive an evaluation report showing at which specific structure(s) of the Chinese characters that the concerned student is relatively weak. In this way, our e-learning system may adaptively provide more such structures for the concerned student to practise.

Basically, there were some initial and positive feedbacks about our work collected from different researchers in the Faculty of Education, and also the School of Chinese in our university or other institutions in Hong Kong. A thorough evaluation will be conducted in a Chinese course offered to foreign students in the upcoming Fall Semester in the University of Hong Kong for a careful analysis. All in all, our work is very promising, and shed sheds light on many interesting directions including the integration with existing online course materials for further investigation on both the pedagogic and technological impacts.ï

Acknowledgments. The authors are grateful to the generous supports from Department of Electrical and Electronic Engineering, the University of Hong Kong. Furthermore, the authors would like to express their gratitude to Dr. Daniel Churchill and Ms. Sue Meng for their fruitful discussions on e-learning systems for writing Chinese.

References

1. Forsberg, A., Bragdon, A., Joseph, J., LaViola Jr., J., Raghupathy, S., Zeleznik, R.: An Empirical Study in Pen-Centric User Interfaces: Diagramming. In: Proceedings of the Eurographics Workshop on Sketch-Based Interface and Modeling 2008, Annecy, France, pp. 135–142 (2008)
2. Li, C.J., Miller, T.S., Zeleznik, R.: AlgoSketch: Algorithm Sketching and Interactive Computation. In: Proceedings of the Eurographics Workshop on Sketch-Based Interface and Modeling 2008, Annecy, France, pp. 175–182 (2008)
3. Goh, T.T.: Kinshuk and Lin, Taiyu: Developing an adaptive mobile learning system. In: Lee, K.T., Mitchell, K. (eds.) Proc. of the International Conference on Computers in Education 2003, Hong Kong, December 2-5, pp. 1062–1065 (2003)
4. Foster, I., Kesselman, C., Nick, J., Tuecke, S.: The Physiology of the Grid: an Open Grid Services Architecture for Distributed Systems Integration. Technical report, Global Grid Forum (2002)
5. Hu, Z.-h., Xu, Y., Huang, L.-s., Leung, H.: A Chinese Handwriting Education System with Automatic Error Detection. Journal of Software, Special Issue on Advanced Distance Learning Technologies 4(2), 101–107 (2009)
6. The eStroke development team: The eStroke Animated Chinese Characters Site (2011), `http://www.eon.com.hk/estroke/` (retrieved: March 10, 2011)
7. The Learning Object team: The Learning Object Site (2011), `http://www.learnactivity.com/lo/index.htm` (retrieved: March 11, 2011)
8. The Wikipedia development team: Smartphone – Wikipedia, the free encyclopedia (2011), `http://en.wikipedia.org/wiki/Smartphone` (retrieved: January 10, 2011)
9. The Xcode development team: the Xcode - Developer Tools Technology Overview website (2011), `http://developer.apple.com/technologies/tools/xcode.html` (retrieved: January 21, 2011)
10. Yeung, K.W.: Mobile Learning of Writing Chinese Characters on UMPCs. A Final-Year Project Report 2008-09, Department of E.E.E., The University of Hong Kong (2009) (revised: March 10, 2009)
11. Yeung, K.W., Tam, V.: An Adaptive Learning Platform to Practise the Writing of Chinese Characters on Ultra-Mobile PCs. In: Proceedings of the International Conference on ICT in Teaching and Learning (ICT 2009), Hong Kong, July 6-8 (2009)
12. Yeung, K.W., Tam, V.: Learning to Write Chinese Characters with Correct Stroke Sequences on Mobile Devices. In: Proceedings of the IEEE 2nd International Conference on Education Technology and Computer (ICETC 2010), Shanghai, China, June 22-24, vol. 4, pp. 395–399 (2010)