**Hybrid Application Development of Chinese Calligraphic Education Based on WeX5**

CHUNPING FANG, JINBAO SONG and XUAN ZHANG

**ABSTRACT**

In this paper, a cross-platform application system of Chinese calligraphic education based on WeX5 is designed and implemented. It’s divided into three functional modules including calligraphic retrieval, knowledge promotion and interactive platform. Moreover, the front-end, back-end and database building process of the retrieval module will be described in detail. In view of the writing animation in the retrieval module, an algorithm based on OpenCV image processing and HTML5 canvas label is designed. Firstly, the Chinese character image is decomposed into the pixels to be filled. Then the pixels are arranged in a certain order. Finally, the image is restored in sequence according to the pixel operation of canvas. Our experiment has effectively solved the problems that the knowledge system of mobile calligraphic education is not systematic, the platform is incompatible, and the interaction is insufficient.

**KEYWORDS**

Online education; hybrid; cross-platform; WeX5; graphics; calligraphy.

**INTRODUCTION**

As a venerable writing art, Chinese calligraphy has always attracted people’s attention. In the age of Internet, people want to learn calligraphy through mobile devices which is still in technical difficulty at present. We’ve summed up the reasons from the following three aspects.

(1). The knowledge system is not systematic. There are five kinds of characters including Kai, Xing, Cao, Li and Zhan in Chinese calligraphy and each kind can be subdivided in accordance with the ages and calligraphers, making it a complex system 1. However, these theories seldom been sorted out by related applications which sometimes exist like forums. For example, we can’t query the order of strokes in those applications (APP) even it’s the first step to learn calligraphy.

(2). The platform is limited. According to literature 23 and the market analysis, we found that people usually gain calligraphic knowledge through offline courses or personal computer. But due to development costs, CPU/GPU limitations and other issues, a professional mobile calligraphic education APP has not appeared in the market.

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The interaction is insufficient. The online interactive mode should be that the client gives the calligraphic knowledge with animated writing demonstration as output, users then complete learning and copy online as input, while in real life teachers teach and student’s practice. There has been a lot of progress in the field of input such as the handwriting generation algorithm based on brush head model processed by Stresemann and the well-known calligraphy simulation software such as Roguish. Whereas, there has not been widely-used algorithm in the area of output.

Aiming at the above issues, the corresponding solutions are proposed by taking the example of developing a calligraphic education APP in this paper. In functionality, the calligraphic knowledge system can be sorted out through the rational module setting. In development mode, cross-platform hybrid APP developed by WeX5 can fill the gap in the Android and IOS market. In techniques, writing animation generated by our algorithm can improve the interaction of APP.

The remainder of this paper is organized as follows: In Section II, related work is briefly reviewed from the above three dimensions. In Section III, the construction of APP and algorithm are fully described. Testing results are presented in Section IV and Section V gives our conclusion.

RELATED WORK

The function module of the existing software

We’ve selected the top-ranked calligraphic software (up to July 22nd, 2017) from Google Play and Apple Store as representatives to analyze how to set functional modules systematically. Characters and Calligraphy in Android is on the left and Copybook for Calligraphy in IOS is on the right as shown in figure (fig.) 1.

The both sides are classified by the chapters of poems. The former can check its characters from the whole chapter, but the targeted knowledge is not given and the strokes animation is not plump. The latter can search by characters, but it comes to a disappointing feedback which simply shows the ancient calligraphers’ copybook.

We can optimize from the below aspects. Firstly, add the classification forms like characters and calligraphers. Secondly, enrich the detailed knowledge like the writing techniques and the origins of the character. Thirdly, optimize the generation algorithm of the strokes animation.

The development models and tools of software

In order to improve the compatibility, we have compared three mainstream software development models as shown in fig. 2.
Among them, hybrid model has not only the cross-platform advantage of web model and the smooth experience of native model, but also the lowest development costs. So it has been the best choice. As the hybrid development tool, the open source tool WeX5 based on Eclipse is chosen. The main body of the H5 APP generated by WeX5 is web view, which is mainly written in the web language HTML5, as shown in fig. 3.

![Fig. 2. The comparison of three development models.](image)

![Fig. 3. The development framework of WeX5.](image)

![Fig. 4. The structure of H5 APP.](image)
H5 APP is comprised by the front-end pages and back-end services. The front-end pages, which consist of components, codes and styles, can call the back-end services. Besides, through the plug-in of Cordova, the application program interface (API) of equipment can be invoked. The structure of H5APP is outlined in fig. 4.

Java is selected as the back-end language. MYSQL is chosen as database. Based on the data and display components WeX5 provides, the setup of the front-end pages and the data transmission from the front-end to the back-end could be completed.

A review of strokes filling technology

The concept of strokes filling was first proposed by Professor Kaide Li, which was explained that the coverage part could remain its status when filled area repeated. Nevertheless, it didn’t take visual effect into consideration. Later, Professor Zhengxuan Wang proposed a filling algorithm that using vertex array to dynamically guide the scanning lines, which can basically restore the writing process. But such problems as rigorous array’s selection and more CPU consumption appear. Besides, the fluent animation can be generated by scalable vector graphics (SVG). However, it's too rigid.

In practice, the method of mask and erase in Flash is most widely used to create gif files embedded in the pages, which has low technical content and smooth animation effect. However, considering the huge Chinese character library, multiple fonts and complicated strokes, the manual operation is not the long-term planning.

In order to solve the above problem, we have designed a new algorithm based on HTML5 canvas label (<canvas>).

The <canvas> was firstly put forward by Apple Inc, accompanied by plenty of 2-dimensional programmatic API that can process images with the lower storage cost. In painting, <canvas> has provided a series of function like stroke(), line to() and fillet(). In graphic processing, the Image Data API can transform the image file and data flow. Our algorithm is the pixel-level image processing operation established on this API.

REPRESENTATION OF H5 APP AND ALGORITHM

The function modules of H5 APP

Combining the analysis from Section II-A, the modules setup scheme in fig. 5 has been provided.
The APP takes retrieval module as the core and the characters as the units, combing through calligraphic knowledge from three query perspectives. The authentic calligraphy shown in poetry query mode impresses user comprehensively, where words can be selected into vertical practice by preferences. In vertical query mode, specific knowledge of a Chinese character in certain font is provided, in which the writing animation simulates tutor's demonstration. Furthermore, users can conduct the horizontal query to comprehend the evolution of characters and recognize the difference among fonts.

The APP has added the functions of simulation animation and real-time copy to improve human-computer interaction. With the function of storage, sharing and forum, human-human interaction is enhanced. Moreover, users can download font packages of different calligraphers or complete expand reading for customization and personalization.

The development of H5 APP

The retrieval module is the core, so we put it into the homepage and the others into the sidebar. Owing to the limitation of the chapter, only the retrieval module will be described in details and the others are abbreviated.

FRONT-END PAGES

In WeX5, the main’s document is created as the index and the display components are added according to the ‘Title-Content-Button Group’ arrangement. The step followed is creating three search pages like ver_search. W, hor_search. W and poem_search. W, which correspond to three query modes. Through the Window Container component, they can be embedded into the same content panel and index can be reused.
In query page, users’ input, including characters and font, should be obtained by the get Element By Xid function, and the show page function that schedules pages can be triggered by on Button Click event (fig. 6a).

In result page, the parameters transmitted from the on Params Receive event are received and back-end services by the send Request function are invoked. Then, the bass Date - the data components to receive response from the database are added (fig. 6b). In the end, the query results are exhibited through a series of display components. Until now, the construction of front-end page is rapidly completed. The functions, event and components mentioned can all be consulted in WeX5 API documentation.

**BACK-END SERVICES**

Data tables and java files should be created in Bass Server. Those self-defining functions in the java files are corresponded to the actions in the data table, and then the communication between the front end and the back end is established.

The functions needed should be written in java files, which for us is multi-table inquires. Fig. 7 is the reveal of some SQL statements. The data type transmitted from the database is table, which needs transforming into json for front-end page to received 9. It can be transformed by the tableToJson function wrapped in WeX5. You can also construct the table and withdraw the specific data.

Fig. 6. Construction of front-end pages. Connection of the front-end and back-end.
DATABASE

Since one character correspond to 5 scripts, two data tables - word and font should be designed. Word is set as primary key to reduce the redundancy as shown in fig. 8.

Until now, we have finished the whole building of query module. Then it comes to the introduction of our algorithm that creates calligraphic animation in the vertical query page.

The strokes filling algorithm in H5 APP

The basic idea of the algorithm is to decompose the character to be displayed into single pixels, then with the processing of OpenCV, the pixels are sequenced in accordance with the order of writing and stored in the database. On the front-end page, the equally large canvas can be created by the Canvas label and the imageData interface can be used to change the corresponding pixels' coordinate, which can finally
achieve the same visual effect as the filling. The algorithm flow diagram in fig. 9 illustrates the principle of sequencing.

Here are some important statements:

- The start, transition and termination of strokes are marked by point [N], the array of guiding points.
- X and Y in the vec array represent the position of a certain point which needs filling in the plane. Z represents the distance from this point to point [0]. The smaller the distance is, the earlier the dot will be filled.
- Point [0] is changing constantly.
- The break point means that when there are too many points crossing the median line between point [0] and point [k+1], the point [0] should be changed. 100 comes from the experimental observation.
- The diameter has stored the number of pixels that have the same distance to point [0] and point [k+1], which can approximately represent the width of the current stroke.
- Use the vector of (point [0]-point[k+1]), which has been normalized by the diameter, to change the location of point[0].
- Flag is number of times that the locations of point [0] changed before the strokes begin to bend. If flag equals 3, it starts to turn the corner at about 75% length of the line segment, which can achieve better simulation effect.

This algorithm draws on the thinking of marking guiding points in Wang’s algorithm, but in essence it’s a sequencing of pixels. The points don't have to be at the border, so it's easier to choose. The result can be stored rather than dynamic programming, so the actual CPU occupation would be sharply reduced, for which it can achieve the same fluency as the SVG method.

In terms of visual effects, this algorithm makes contribution either. Firstly, sequencing by distance makes the filling line a curve, which can deliver better simulation comparing with the linear scan. Secondly, because of its processing space without closure, unique artistic beauty like “flying white” and “dry ink” can be presented. Lastly, as the number of pixels that can be modified in a unit time is regular, the filling accelerates when the strokes get slender, coincident with reality, while other algorithms cannot accomplish easily.

![Algorithm flow diagram](image-url)
EXPERIMENTS

Typical function test of the APP:

Compatibility test in the typical mobile-end:

Algorithm running test in generating animation of typical bending strokes:

CONCLUSION

This article has presented the development of a hybrid calligraphic education APP. Firstly, A proper functional module framework can systematized the calligraphic knowledge. Secondly, hybrid APP developed by WeX5 can solve the compatibility problem. Finally, the strokes filling algorithm proposed in this paper can create interactive animations. The experiments demonstrate our theory.

In conclusion, the project is of creativity and practical engineering value, promoting the traditional Chinese culture and the development of calligraphic education.
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