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# Stroke++: A new Chinese input method for touch screen mobile phones ☆

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ABSTRACT

Over the past few decades, users have been feeling clumsy inputting Chinese on mobile devices, partly because the layout of the keyboard/keypad is originally designed for inputting Latin alphabets. To improve this user experience, we propose Stroke++, a novel Chinese input method for touch screen mobile devices. More specifically, Stroke++ provides efficient keypad layout, a friendly user interface and a intelligent character/phrase candidate set generation algorithms. Stroke++ splits a Chinese character into multiple radicals. By leveraging hieroglyphic properties of Chinese characters, our method requires users to only input a subset of the radicals to identify the target character, making it much faster and easier to input Chinese on mobile phones. Our user study results show that Stroke++ outperforms most major Chinese input methods on mobile devices, including Stroke, Pinyin and Hand Writing Recognition (HWR), in terms of the input efficiency and usability. Moreover, we also demonstrate that Stroke++ offers a low entry barrier for Chinese-input novices.



## 1. Introduction

Both the standard QWERTY keyboards on PCs and the typical ITU-T keypads on mobile devices were originally designed for Latin alphabets. Therefore, inputting Chinese characters on these standard keyboards can be awkward and clumsy, especially on mobile devices where the keys are tiny. For many years, users have been desiring to efficiently and intuitively input Chinese characters on mobile devices.

Before touch screens were widely adopted on mobile devices, much work has been done to find an optimal mapping between Chinese characters and Latin-based keyboard layouts. Pinyin and Wubi are the most commonly used methods on computers, closely followed by Stroke, namely Wubihua (ROC), an inputing method based on the stroke order of a character. Based on the analogy with capital Latin letters and the decomposition of characters into basic shapes, UniGlyph (Poirier et al., 2007) allows for typing text on a 4-button minimal keypad with only one keystroke per character. The authors of Belatar and Poirier (2008) further presented a new implementation of this method for users with motor impairments. The authors of Tseng and Chen (2006) have also evaluated the feasibility of the Chinese input method based on the first Mandarin phonetic symbols of the syllables of characters. Currently, Pinyin is still the dominant Chinese input method for mobile users.

Among the above methods, some use standardized rules to latinize Chinese characters (ROC; Liu and Räihä, 2008; Liu and Wang, 2007), like Pinyin, while others, such as Wubi and Stroke, make use of the stroke or radical properties of Chinese characters to map a sequence of key strokes to a certain character.

All these methods heavily rely on the physical keyboard layouts, such as QWERTY on PCs and ITU-T on mobile phones. Users have to remember both the layouts and the key mappings in order to type efficiently. For example, one might have to remember a whole set of 'root' combinations on a QWERTY keyboard, as shown in Fig. 1, as well as the position of each 'root' in a character, in order to type in Chinese characters using Wubi.

As for modern mobile phones, new input methods such as T9 Pinyin and Phrasal Pinyin (Liu and Wang, 2007), which index all the characters by their syllable, have been developed to help people input Chinese faster and more easily, as shown in Fig. 2 (middle). These methods made significant improvement on typing speed by allowing users to type multiple characters by much fewer key strokes. However, in different parts of China, same characters can be pronounced differently because of the dialects in different regions. These above-mentioned input methods on the other hand are only based on standard Pinyin pronunciation. Users who are not used to the Pinyin's pronunciation system (e.g., Cantonese or other dialects' speakers) are hardly able to make use of these

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Pinyin-based input methods. They still face a lot of difficulty in entering Chinese on mobile phones.

One alternative for such users is Stroke-based input methods. However, these methods put a significant burden on users by implicitly requiring users to know exactly how to write the target Chinese characters in the correct stroke order. Given the complexity and variations of Chinese characters, this requirement is extremely challenging and unreasonable.

Wubihua, as shown in Fig. 2 (left), is one of the most easy-to-learn input methods based on strokes. It is intuitive and puts no requirement of the knowledge of character pronunciation. Unfortunately, it suffers from a severe shortcoming, i.e., a typical Wubihua code is very likely to match tens or hundreds of characters, thus users need to make selection of the target characters from these tens or hundred candidate characters. The strict stroke order sometimes also prevents users from finding the target character with their own stroke sequences. Kansuke (Tanaka-Ishii and Godon, 2009) is a logograph look-up interface based on three modified stroke prototypes: horizontal, vertical, and other strokes. This method makes it easier for language novices to look up Japanese and Chinese logographs. However, it has the limitation that users must know how to write the character exactly and count the number of three prototypes.

By employing a combination of abstract symbols and example strokes to help users map strokes to keys more effectively, a design solution (Lin and Sears, 2005) demonstrates that stroke-based solutions for Chinese character entry can be effective alternatives for mobile phones, especially for the users who can write Chinese but do not speak Mandarin fluently.

Unlike most text input methods for mobile devices that rely on repeatedly pressing buttons, a gestural text entry method (Wobbrock et al., 2007) uses an isometric joystick and the EdgeWrite alphabet to allow users to write by making letter-like “pressure strokes”. In the last few years, touch screens and multi-touch technology have brought Hand Writing Recognition (HWR) onto mobile phones (Wayne, 1999; Shi et al., 2003; Ao et al., 2007), as shown in Fig. 2 (right). These techniques have eliminated much of the trouble existing in key-based input methods, but they are not optimal in terms of input speed and accuracy. Though much improvement has been made on Chinese input methods in the past two decades, some elderly users or the users with different dialects still cannot come to terms with the texting feature or other text-based communication methods on their mobile devices.

Leveraging hieroglyphic properties of Chinese characters, we propose Stroke++. Stroke++ provides users with an much easier and faster solution to input Chinese. It decomposes Chinese characters into radicals—the structurally basic components of Chinese characters—and then places them onto a customized touch screen-based layout. A series of algorithms are designed to allow users to input Chinese characters with the least knowledge of stroke orders or pronunciations of characters. Our major contributions are summarized as follows:

- We obtained 200,000 SMS (Short Message Service) messages from China Mobile, and extracted 42 Chinese radicals from the characters in these SMSes. We manually decomposed 6763 Chinese characters into radicals to build a radical-Chinese character database.
- Based on the database, we proposed Stroke++, a method using radicals to input Chinese characters, including the phrase and association input, and optimized the input speed of the most frequently used characters. Stroke++ is easy to learn, and even a non-Mandarin speaker can use it to type in Chinese characters based on their physical geometry.
- Based on Nokia Qt and Symbian V5.x platforms, we evaluated Stroke++ with 52 participants from three representative cities in China. We conducted a series of user studies to test the user interface and performance of Stroke++. The experimental results show that Stroke++ is a competitive Chinese input method.

The reminder of this paper is organized as follows. Section 2 describes the layout design of Stroke++. In Section 3, radical matching algorithm is discussed. Explanatory case studies are given in Section 4. In Section 5, we present our Chinese character/phrase generation algorithms. In Section 6, the performance of Stroke++ is evaluated through user studies. Section 7 concludes this work.

## 2. Hybrid layout design

### 2.1. Radical selection

There are 6763 Chinese characters in the GB2312 character-set, while the number of the most commonly used characters in daily SMS is very limited. We analyzed 200,000 real life SMS messages from China Mobile, and found that only 4329 different characters were ever used, among which the frequency of the top 600 characters is 92.9% (Yan, 2009; Niu et al., 2010). Based on this observation, we focused on improving the input efficiency of the top 600 characters and guaranteeing all the 6763 characters can be inputted by this method.

There are 185 different Chinese radicals in total. Due to the limited number of keys in our virtual keypad, it is impossible to assign each of these radicals to a dedicated key. Therefore, we chose the most frequently used 42 radicals in the top 600 characters to form the basic set of radicals of Stroke++. The appearance frequencies (the counts of radicals in the 600 characters/600) of the top 30 radicals for the most frequently used 600 Chinese characters are shown in Fig. 3. The five most basic strokes (“一”, “丨”, “丿”, “丶” and “乛”) used in Stroke are preserved to help users enter the characters that are hard to be split into radicals intuitively.

### 2.2. Layout design

The virtual keypad layout was designed partly based on Chinese characters′ “square” shape, which has not yet been fully considered in the earlier Chinese input methods. Because of the limited number of the virtual keys, some similar radicals were grouped together to share one key. By analyzing our eye tracking data, we found that the users tend to search the layout grid in the direction where the radical resides in the character. For example, “亻” normally sits in the left of characters, so when users try to find “亻”, they usually look for it in the left portion of the layout first.


**Fig. 1.** Wubi QWERTY keyboard layout. Each key is associated with multiple ‘roots’. This kind of input method sets a relatively high memory barrier for users.