Abstract

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# Introduction

## Online Hand Writing Recognition

The field of personal computing has begun to make a transition from the desktop to handheld devices, thereby requiring input paradigms that are more suited for single hand entry than a keyboard. Data entry using a pen or even by using the finger forms a natural, convenient interface.

The large number of writing styles and the variability between them makes the problem of writer-independent unconstrained handwriting recognition a very challenging pattern recognition problem.

Nowadays, the primary mode of data input from a human to a computer is still the keyboard. However, the amount of information processed by computers is rapidly increasing. Given this, the time consumption of information exchange between human and computers is becoming a serious bottleneck. In order to be effective, the user interface has to be both effective and natural. Thereby, requiring no learning curve to the user. [1]

[Talk about smartphones/Tablets/etc.]

While much of the today’s data is directly entered into computers using the keyboard, many tasks still exist in which people tend to prefer handwriting over keyboard entry. Note taking (e.g. in classrooms) is a task that can still be done more efficiently by hand for most users. In addition, while people can produce annotated hand sketches very quickly, data entry into a computer using a combination of the mouse and keyboard is relatively time consuming. [1]

Smartphones and tablets are pocket sized consumer devices that can store calendars and address books, provide access to emails, the web, and contain other productivity tools. These devices are too small to have full sized keyboards, or sometimes may be too small for any keyboard at all, requiring pen, hand gestures, figure gestures or voice interface to enter data. [1]

The problem of handwriting recognition has now been a topic of research for over four decades. There are many types of problems (with varying complexity) within handwriting recognition, based on how the data is presented to the recognition system, at what level the data can be unambiguously broke n into pieces (e.g. individual characters or words), and the transcription complexity of the language used. [1]

At the highest level. Handwriting recognition can be broken into two categories: offline and online. Offline handwriting recognition focuses on documents that have been written on paper at some previous point of time. Information is presented to the system in the form of scanned image of the paper document. In contrast, online handwriting recognition focuses on tasks where recognition needs to be performed at the time of writing. This requires the use of special equipment, such touch screen or digitizing tablet, to capture the strokes of the pen as that are being written. The trace of a writer’s pen is stored as a sequence of points sampled at equally spaced time intervals. The information captured for each sample is the  coordinates. While this sequence can be used to construct a static image of the writing, thus allowing offline character recognition techniques to be applied, it has been shown [63] that the information about the pen dynamics can be used to obtain a better recognition accuracies than the static data alone. Therefore, it is beneficial to capture the data in an online form, even if the real-time processing requirements can be relaxed. [1]

Another advantage of online handwritten data over offline data is the availability of the stroke segmentation and the order of writing. Ink in static images must first be separated from the image background, creating a potential source of error. The ability to detect the states of “pen-down” (when the pen touches the tablet or the finger touches the touch screen) and “pen-up” can also be used. A single stroke is defined as the sequence of sample points occurring between consecutive pen-down and pen-up transitions. However, a complication occurs when a stroke is added to a character in a word after the rest of the word has already been written, such as the cross of a ‘t’ or an ‘x’, or the dot of an ‘i’ or a ‘j’. These types are called delayed strokes. [1]

## Characteristics of Arabic Script

The Arabic Aleph bet is widely used for more than twenty different languages such as Farsi, Urdu, Malay, Housa and Ottoman Turkish. [2]

Arabic Scripts consists of 28 basic letters, 12 additional special letters, and 8 diacritics. Arabic script is written from right to left in a semi-cursive manner in both printed and handwritten. Most letters are written in four different letter shapes depending on their position in a word, e.g., the letter ع (Ain) appears as ع (isolated), عـ(initial), ـعـ (medial) and ـع (final). Among the basic letters, six are Disconnective – ا (Alef), د (Dal), ذ (Thal), ر (Reh), ز (Zain) and و (Waw). Disconnective letters do not connect to the following letter and have only two shapes each. The presence of this letters interrupts the continuity of the graphic form of a word. We denote connected letters in a word, as word-part. If the word-part is composed of only one letter, this letter will be in its isolated shape. [3]

The Arabic script is different from the western scripts in that it combines letters into words. [2]

Certain characteristics relating to the obligatory dots and strokes of the Arabic script distinguish it from Roman script, making the recognition of words in Arabic more difficult than in Roman script. First, Most Arabic letters contain dots in addition to the letter body, such as ش (Sheen) which consists of س (Seen) body and three dots above it. In addition to dots, there are stroke that can attach to a letter body creating new letter such as ك, ط and لا. These dots and strokes are called *delayed strokes* since they are usually drawn last in the in handwritten word-part/word. Second, eliminating, adding or moving a dot or stroke could produce a completely different letter and, as a result, produce a word other than the one that was intended (see Table 1). Third, the number of possible variations of delayed strokes is greater than those in Roman scripts, as shown in Figure 2. There are only three such strokes used for English: the cross in the letter *t*, the slash in *x*, and the dots in *i* and *j*. Finally, in Arabic script a top-down writing style called *vertical ligatures* is very common – letters in a word may be written above their consequent letters. In this style, the position of letters cannot be predefined relative to the baseline of the word. [3]

Saabni and El-sana have explored a large collection of Arabic texts and extracted 300,000 different word combinations of 82,000 different word-parts. Ignoring the additional strokes reduced the number of different word-parts to 40,000. [2]

# Bibliography

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| [1] | S. D. Connell, "ONLINE HANDWRITING RECOGNITION USING MULTIPLE PATTERN CLASS MODELS," Michigan, 2000. |
| [2] | R. Saabni and J. El-sana, "Efficient Generation of Comprehensive Database from Online Arabic Script Recognition". |
| [3] | F. Biadsy, R. Saabne and J. El-Sana, "Segmentation-Free Online Arabic Handwriting Recognition," 2010. |