

Title	隠れマルコフモデルに基づくオンライン手書き文字列認識に関する研究
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On-line Recognition of Handwritten Text Based on Hidden Markov Model

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1 Introduction

As the downsizing of the mobile devices such as personal digital assistants (PDAs) and cellular phones progresses, online handwritten character recognition has been regarded as the promising key technology for the character-based input interface in mobile environment in recent years. Moreover, since the interface using handwritten character recognition is suitable for those people of advanced ages who are not used to computer-keyboards but used to writing characters, it is becoming much important to improve the character recognition performance to provide those people with better accessibility to the information society.

However, in most of the online handwritten character recognition interfaces in practical use, people are forced to write each letter separately and specify the character boundaries. This type of input method is not preferable because it interrupts the thought of the writers and makes them unpleasant. Therefore, the aim of this thesis is to develop a new online handwritten character-based interface, in which people can write any sequence of letters without specifying the character boundaries.

2 Stroke HMM

The approach of online handwritten character recognition based on stroke HMM similar to relation of speech recognition and online handwritten character recognition. Basic idea of Stroke HMM is that we treat a Kanji character as sequence of strokes. In this method, velocity vectors of pen movement are input features, the pen movements in the 8 directions are modeled by 25 kinds of substroke HMM, Kanji dictionary is hierarchically defined by substroke unit, and recognition results are obtained as maximum likelihood path searched by Viterbi decoder. In the expression of every Kanji character by only 25 kinds of HMMs, a high-speed character recognition by a small-scale dictionary is possible, and promising as the character recognition technique of a mobile environment.

A further expansion of online handwritten character recognition based on stroke HMM constructed online continuous handwritten character recognition with using the language model by applying the technique of a continuous speech recognition.

3 On-line Handwritten Text Data

We collected two kinds of online handwritten continuous character data. One is writing-direction-arbitrary continuous character data which made the move direction in a character unit arbitrary directions, the other is overlapped writing continuous character data which assumed continuous character input to the Personal Digital Assistant of a small input screen.

These continuous character data included the following features: the individual variation of the writing directions such as horizontally-written and vertically-written, the inclination of the continuous character by the change of the writing direction, scribbles writing such as continuous strokes and crumble, an overlap of the drawing between characters, and so on.

4 Writing Pressure Features

New use of pen pressure as a feature was proposed for the improvement of a basic performance of the writer-independent online handwritten character

recognition technique based on stroke HMM.

I propose two kinds of features related to pen pressure: one is the pressure representing pen ups and downs in a continuous manner; the other is the time-derivative of the pressure representing the temporal pattern of the pen pressure. Combining either of them with the existing feature (velocity vector), a three-dimensional feature is composed for character recognition. Some techniques of interpolating the pen pressure during the pen-up interval is also proposed for a preprocessing purpose.

Through experimental evaluation using 1,016 elementary Kanji characters compared with the baseline performance using velocity vector only, the additional use of pen pressure improved the performance from 96.90% to 97.77% for careful writing and from 90.30% to 92.37% for scribbles. Moreover, achieved robust recognition for stroke fluctuation of cursive writings.

5 On-line Recognition of Handwritten Text

Online handwritten text recognition system was constructed by using one-pass beam search and language model used by continuous speech recognition. Therefore, cutting out and the character boundary detection in the writing area became needless. Moreover, the overlapped writing continuous character recognition was achieved by using the feature (speed, direction, and pen pressure) which did not depend on position information. In addition, writing-direction-free continuous character recognition including overwrite was achieved by the generalization of the writing direction to adjacent character in the character boundary.

The result of experiment performed on overlapped writing using vocabulary dictionary was composed of 1,016 elementary Kanji characters and 71 Hiragana characters revealed a string-level recognition rate of 88.79% and a character-level recognition rate of 94.52%.

6 Conclusion

Online handwritten text recognition based on stroke HMM was constructed by using language model. New use of pen pressure as a feature was proposed for the improvement of a basic performance. The overlapped

writing input method to assume a small mounting the input screen on the Personal Digital Assistant and visual disturbance person's input device was proposed. And the writing-direction-free text recognition including overwrite was achieved.