International Journal of Innovative Computing, Information and Control
Volume 5, Number 3, **March 2009**

ICIC International ©2008 ISSN 1349-4198
pp. 653–659

Development of Pen-based Note-Taking System for Persons with Visually Disabilities

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Received Feb. 2008; revised Aug. 2008

ABSTRACT. *We frequently take notes when attending class. The method of note-taking includes writing much information as a paper record. However, we cannot write such notes in a notebook if no visual feedback information exists. We propose a pen-based note-taking system, designated as the Pen-Talker, for a visually disabled person to use on an ultra-mobile PC. Using the Pen-Talker, a blind novice user with acquired blindness can input Japanese characters directly instead of through a keyboard without much training. This paper describes the system design concept. We also investigate a higher level recognition engine based on hybrid recognition, which integrates on-line and off-line recognition algorithms; we restructure the input interface using the ultra mobile PC with a voice-assistance function. Screen information is given to users via a built-in a screen reader. Therefore, the Pen-Talker is useful as note pad software using a button operation that is simple for even a blind novice user. Recognition experiment results show that recognition accuracy has improved to 93.3% for eight blind subjects, which is an extremely high score compared to that of our previous system. Results confirmed the possibility of practical use of the proposed system.*

Keywords: Pen-input system, Handwriting recognition, Visually disabled, Tablet PC

1. **Introduction.** The number of visually impaired persons is increasing because of eye diseases and traffic accidents. Of them, about 200,000 people in Japan have developed acquired blindness. Blind people have been interested in computer use as a communication assistance mode. In general, users are able to input a Japanese character using a keyboard on desktop PC. Notwithstanding, because a blind user cannot see the key position, keyboard operation is onerous. Furthermore, the Japanese language typically requires the use of about 3,000 commonly used characters of kanji (Chinese characters), hiragana, and katakana. For those reasons, computer support for blind people has become an important theme. A word-processor using a keyboard is commercially available for blind users today. However, users must learn to use the process of software conversion from kana to kanji using a keyboard. This software must select the proper kanji character from among various

candidates of the same kana sound (called homonyms). Consequently, keyboard operation is not a suitable method for novice users in Japan.

As one computer support method for blind users, we have proposed an on-line Japanese character input system for people with acquired blindness [1-4]. Although blind users are still required to select the candidate characters, when the character is input using a stylus pen, the burden on the user is reduced because of the development of a high-accuracy character recognition algorithm. For realizing this system, the recognition method must recognize the handwritten character without visual feedback. Therefore, we propose a new recognition technique in addition to advanced recognition accuracy. Fortunately, almost all persons with acquired blindness have memorized the shapes of basic Japanese characters. Therefore, a novice blind user is able to input Japanese characters without training in our system.

This paper presents a pen-based note-taking system as a learning support system of a blind person. First, we describe the system design. Next, we describe how to use the system, in addition to a method of improving the character recognition accuracy. Finally, the proposed system is examined in terms of the input time and recognition accuracy with the participation of eight blind novice users.

2. Character recognition for blind users.

2.1. Recognition algorithm. Japanese users are expected to use many characters of various kinds. In recent years, word processors which use a keyboard have become commercially available for blind users on the information technology market. However, users must learn to use the input method editor (IME), which is the conversion software of kana to kanji characters, using a keyboard. This software must select the appropriate kanji character from among various candidates that have the same kana pronunciation (homonyms). Consequently, the keyboard operation is not a suitable method for novice blind users in Japan.

As a computer support method for blind users, we have proposed an on-line Japanese character input system for visually disabled persons (particularly those with acquired blindness). Structural analysis is very useful to assess deformed handwritten characters [5-6]. However, this method cannot be used for characters written by a blind person because the stroke positions are unstable, as shown in FIG. 1. We investigated characteristics of Japanese kanji characters written by many blind persons. From the analysis results, we found the following stable features [2].

(1) The same blind person can write almost the same stroke shape, stroke number, and stroke writing order.

(2) The relative positions of the representative stroke points in the partial pattern are stable.

FIGURE 1. Examples of handwritten Japanese characters written by blind users.

Two character recognition algorithms—the RDS method and the LSDS method—have been proposed for this system as previous recognition algorithms for blind users. The RDS method is based on the relative direction between two adjacent strokes in a writing order. We represent each stroke of the Japanese character using three typical points (a starting point, a middle point, and an ending point). Furthermore, a stroke is divided into several line segments by the same segment length. A feature parameter set is expressed as a set of eight directional codes that correspond to each line segment. This recognition method is called the LSDS method (a method based on the line segment directions in a stroke). The combination of the two methods is desirable to recognize various Japanese characters written by the blind person because these methods use a different type feature.

Many characters having a small number of strokes (such as hiragana and katakana) were contained in the mail texts when our recognition system was applied to the application of the electronic mail software for use of the blind. Previous experimental results show that the character recognition accuracy was decreased significantly because the features decreased [7-8].

2.1. Integration of on-line and off-line character recognition algorithms. We investigated the causes of misrecognition in detail. Results implied the main cause was extraneous strokes included in the stroke data: blind users made touch mistakes because they were unable to see the surface of the tablet and the pen point. This phenomenon was more or less frequently generated according to the person. However, we found also that the positional deformation between strokes is slight for characters having few strokes. Therefore, we are able to use hybrid character recognition integrating off-line algorithms and our previously developed on-line character recognition, as presented in FIG. 2.

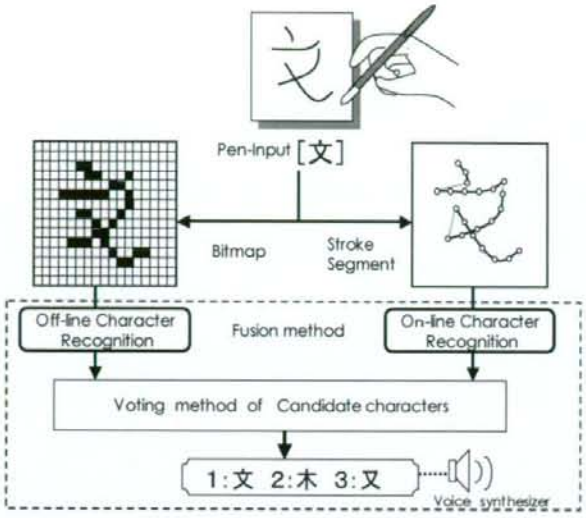

FIGURE 2. Integrated character recognition of two types: Off-line and On-line recognition.

Hybrid character recognition has high recognition performance, even when the character pattern is input with a markedly different stroke order and stroke number. Because off-line recognition uses a bitmap pattern as the recognition object, it is unaffected by variations in the stroke writing order of the input pattern [9]. This method is effective for low-stroke-number characters written by a blind person. However, because the influence of the character deformation increases when increasing the number of strokes, we will change the weight of the score of two recognition results according to the number of strokes of the input character. Consequently, we developed a note-taking system for blind user. In our new system, we reconstruct a recognition method which uses our previously developed on-line recognition algorithm and another commercial hybrid character recognition algorithm [10]. The voting method is used for the integration of the two recognition engines with weights determined according to number of strokes based on the preliminary evaluation experiment.

3. Design of the *Pen-Talker* system.

3.1. System configuration. We have developed an on-line Japanese character input system on the desktop PC for a blind person. This desktop model comprises a personal computer with a control board that includes an electronic tablet [4]. For this study, we apply the pen-based note-taking system to an ultra-mobile PC (UM-PC) for ubiquitous computing support of blind users. We used some command functions of the desktop model. However, the UM-PC has only a few standard command buttons. Therefore, we redesigned the system interface for the new note-taking system, which is designated as a *Pen-Talker* for this discussion. The system has a built-in screen reader for assistance of the screen information and system guide.

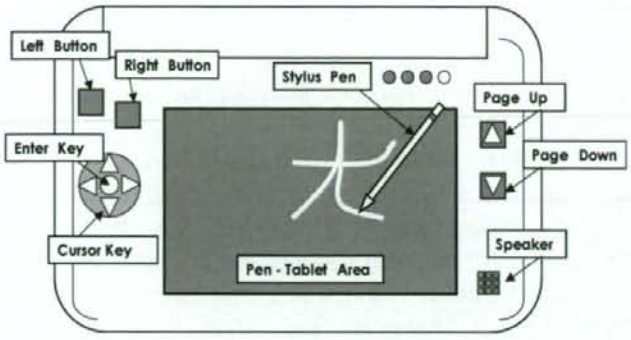

FIGURE 3. Command button arrangement of the *Pen-Talker* (Ultra-Mobile PC, Windows XP Tablet Edition 2005 ™; Microsoft Corp.).

FIGURE 3 presents the button arrangement of the *Pen-Talker* (this example model is for a right-handed person). The system has a tablet function on the 800 × 480 touch-screen display (CPU, VIA C7-M 1.0 GHz; RAM, 512 MB; HDD, 40 GB). Therefore, the user can write a character on the display directly using a finger or a stylus pen. Furthermore, there is a step in a character entry box for simplified descriptions for blind users. In general, a right-handed user holds the body using the left hand and writes a character using the right hand. The *Pen-Talker* has two mouse buttons—a [Left] / [Right] button, four direction-cursor keys and the [Enter] key on the left side of the surface panel, as shown in FIG. 3. We use these buttons and keys as the control button in the system. The input character operation is very simple; all buttons can be checked easily using the tactile sense of the blind user's finger. The [Left] button is usually synchronized with the pen down. The [Enter] key is used for determination, such as a decision of a candidate character, selection of a sub-mode menu, and decision of one-character input. The [Up] / [Down] cursor keys are used for the selection of candidate characters. The [Left] cursor key is used to erase one character. The system reads out one phrase in the text box when the [Right] cursor key is pushed.

3.2. Text input procedure. The character input method is the following procedure. First, the *Pen-Talker* starts automatically when the user pushes the power switch. The system shifts after a moment to the character-writing mode. Next, the user writes one character to the entry box on the screen display using a stylus pen and pushes the [Right] button. Then, the system begins to recognize a character using the hybrid character recognition method. Subsequently, the system outputs the first candidate character on the display and the voice synthesizer announces the first candidate character. The user can make a text input by repeating the same procedure if a correct answer is announced. The user selects other candidate phrases using the [Up] / [Down] cursor key with scroll operation if a wrong answer is announced. The user pushes the [Left] cursor key when there is no correct character among the best 20 candidates. The system then reverts to the character-writing mode. These mode statuses are frequently announced using a voice synthesizer when the system changes the mode condition.

4. **Evaluation of recognition accuracy.** We examined the character recognition accuracy and character input time of the *Pen-Talker* system. The experiment involved eight blind subjects (six men and two women) who wrote non-learning 112 Japanese characters in six letter examples according to the voice guide of an experimenter (FIG. 4). Subjects were 38–57 years old (average, 49 years old). Seven subjects had no well-trained touch-typing skills and little experience using a personal computer. TABLE 1 shows the average number of input characters per minute using the *Pen-Talker*. The number of characters that were input in one minute was 14.6, on average. In other words, the average input time of one character is about 4 s. The time of recognition per character is about 20 [ms]. Therefore, the remainder is time for handwriting and the voice output. We confirmed that all subjects were able to use the Japanese character input operation using the *Pen-Talker*. The total average of the recognition accuracy was 93.3% for the first candidate and 98.4% for best three candidates (TABLE 2). Therefore, we also confirmed that the improvement method was more useful than our previously described recognition algorithm.

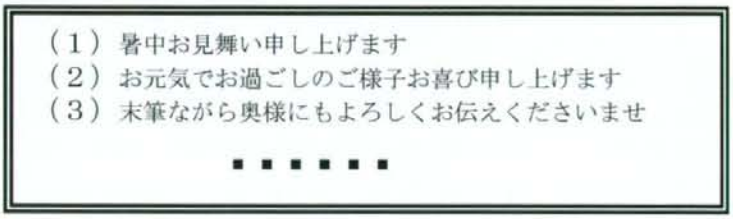

FIGURE 4. Examples of the letter text for the experiment

TABLE 1. Comparison of the average number of input character per minute

[Unit: Number of character/min]

	1st trial	2nd trial	Average
Total Ave.	13.2	16.0	14.6
Max.	17.8	20.5	19.1
Min.	9.6	12.8	11.2

Input data: Non-learning 112 Japanese characters (Letter example)

Eight blind subjects (six men and two women)

TABLE 2. Character recognition accuracy according to the experimental results

[Unit:%]

Recognition Accuracy	First Candidate	Best two Candidates	Best three Candidates
1st Trial	92.7	97.2	98.3
2nd Trial	93.9	97.3	98.5
Total Ave.	93.3	97.3	98.4

5. **Conclusion.** We developed a note-taking system, named the *Pen-Talker*, for blind users (particularly people with acquired blindness). With only slight training in the system, a blind user can input Japanese characters directly instead of using a keyboard. *Pen-Talker* can recognize 3,126 characters, which includes all JIS Level 1 characters. This paper describes the *Pen-Talker* system design concept. Furthermore, we investigated the Japanese character recognition performance for the practicable Japanese input situation such as taking notes and writing. Many characters with few strokes were included in the mail text when the previous system was applied to an E-mail system. Therefore, the recognition accuracy was decreased. For improvement of the recognition accuracy, we installed a hybrid character recognition algorithm to the *Pen-Talker* system engine. Using the experimental result, we confirmed that novice blind users were able to use the *Pen-Talker* as a note-taking system: it is very useful for mobile computing systems. The advantage of this system is that it can function as an information terminal device for mobile computing for all blind users.

Acknowledgment. The authors are very grateful to Dr. Kazushi Ishigaki and Dr. Hiroshi Tanaka of Fujitsu Laboratories Ltd. for their continual assistance in the development of our technologies.

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理療現場におけるペン入力を用いた診療データ記録に関する研究

Study about Medical Data Storing System for Acupuncture by using Pen-input

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1. はじめに

厚生労働省の調査によると，全国には 30 万人を超える視覚障害者がいる．このうち，疾病や交通事故などにより中途失明した人の割合は過半数にも達し，高齢化社会の進行に伴って糖尿病などに起因する中途失明者が増加する傾向にある．そこで我々は，昨年度から，理療の臨床実習においてペン入力方式を利用してデータ記録作業をスムーズに行なうことの出来る「診療データ記録システム」に関する研究[1]を行っている．

昨年度は患者が問診表を記述する際に，デジタルペンを利用することにより，患者データがデータベースに記録され，理療師が音声出力により内容確認が可能になる機能の実装を行なった．

そこで本稿では，施術中に理療師もデジタルペンを用いて施術記録を記録することで，施術内容が自動的にデータベースに記録され，後で音声により確認可能な機能の実装方法について述べる．

2. システム構成と処理の流れ

図 1 は提案する理療データ記録･閲覧システムの構成図で，処理の流れは以下の通りである．①患者が初診時にデジタルペンを用いて問診票に筆記を行なう．このとき，事務員はデジタルペンのメモリーユニットをコンピュータに接続する．②受付用 PC は，メモリーユニットから筆跡データを読み取り，文字認識を行なった後に，自動的に患者データをデータベースに登録する．③理療師はデジタルペンにより患者データを検索可能で，音声出力機能により閲覧（聴取）可能となる．④施術の際には，デジタルペンを用いて理療師が所見や処方のデータを記録する．⑤施術が終わった後に，所見や処方等を記述すると，文字認識が行なわれ，診察・処方用のデータベースへ記録される．

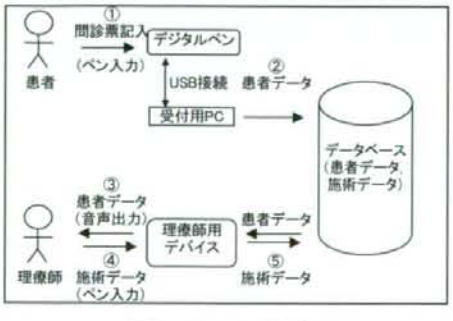

図 1　システム構成図

3. 理療師用デバイス

理療師用デバイスには，音声出力機能をもったコンピュータとぺんてる社の電子ペンである airpen[2]を使用する．airpen のオンライン接続機能を利用し，手書きデータをリアルタイムでコンピュータに入力する．記録の際には図 2 のようなテンプレートを用いる．各記入欄には段差が設けてあり記述箇所が分かるように配慮してある．また，図 3 の様に airpen バインダーに挟んで使用する．

診療データ記録の際には以下の二つのモードを用意する．

① 患者データ閲覧モード

データベースに登録された患者を検索し，患者データを閲覧するモードである．ここで記入する項目は患者名のみである．そのため患者名欄を他の欄とは少し離れた位置に配置し区別をつけている．患者名を記入すると，コンピュータ上に該当患者がリストアップされる．目的の患者を決定した後，所見等の患者データを読み上げる．

② 施術記録モード

理療師による施術結果を記録するモードである．このモードでは所見，施術内容と経過の欄を使用する．実際に施術を行った後，所見や施術内容等を記入し，Enter をペンで触れることで記入された内容が文字認識され，データベースへ登録される．

図 2　記入用テンプレート

図 3　使用時

なお，書き間違いが起こった時は Delete をペンで触れることで記入中の欄の内容を消去出来る．また，テンプレートの左隅と右隅に小さな四角形の穴を開け，ペンで四角形に触れることでモード切り替えを行なう．

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