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Realtime Character Recognition from a Remote Terminal

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1. *Introduction*

Recently, a few realtime character recognition schemes have been developed for computer input [1]~[4].

Here, realtime character recognition is defined to be a technique which processes those figures drawn on a tablet and recognizes them as a character in a fairly short time. Objects of recognition may be general figures such as flow-chart symbols, but this paper confines itself to characters as their representative.

Many researchers have focussed their attentions mainly on recognition algorithms and seem to pay less attentions to such problems as to recognize characters written from a remote terminal, or to use a simple and economical graphic input tablet, which should be solved for practical applications.

Such problems as economy, an easy transmission, or use of conventional communication lines would be very important in a situation that anybody can use a big center computer at any time from any place. In consideration of economy, simplicity, and an easy signal transmission, a conventional tele-writer called "Telemail"** which transmits a signal through a telephone line was employed as a graphic input device and a realtime character recognition from a remote terminal has been attempted. Furthermore, a man-machine communication system named "CRIARS"*** was built which receives input information through realtime character recognition and outputs messages in computer synthesized speech.

2. *Realtime Character Recognition Scheme*

2.1 *Hardware*

Hardwares of this realtime character recognition scheme are shown in Fig. 1 as a part of the CRIAR system. The prime part of the system is a computer, NEAC-L3, which has a memory capacity of 8192 words (36 bits/word) whose cycle time is 6.5μs. It is equipped with 8 magnetic tape units, a magnetic drum of 65 Kwords, and a switch box for input from and output to external equipments.

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** Telemail: A registered trade mark for a product of Nippon Electric Co., Ltd.

*** CRIARS: An acronym of Character Recognition Input and Audio Response System.

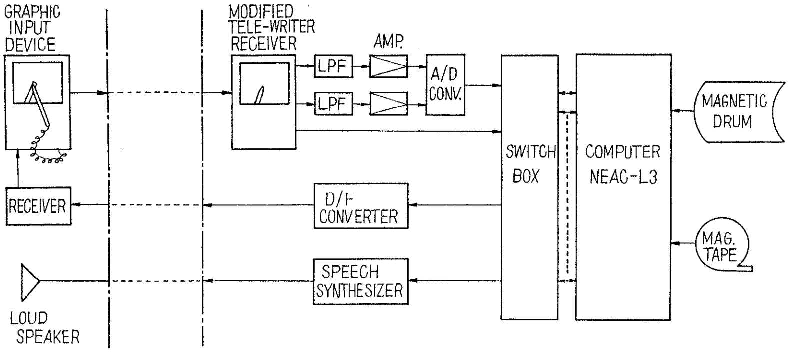

Fig. 1. The hardware system of CRIARS.

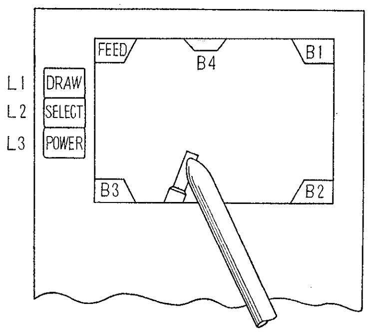

Fig. 2. The drawing area of the input device and control buttons.

Both tele-writer transmitter and receiver have rectangular writing areas of about 9×13 cm as shown in Fig. 2. A pattern drawn with a ball-point pen on the writing surface of a transmitter is duplicated on the receiver. Two signals are generated in the transmitter, whose frequencies change according to a pen location. A pressure-sensitive micro-switch is implemented in the pen and generates a signal to show pen up or down. These three kinds of signals ranging from 100 Hz up to 3 KHz in frequency are modulated together and can be sent through a conventional telephone line.

As shown in Fig. 1, a modified tele-writer receiver is used for a frequency to voltage conversion process in the system. Coordinates are expressed in a digital signal of 20 bits and input into the computer. The sampling period of the coordinate signal is about 10 milliseconds which is governed by an input program and is not necessarily constant.

The computer controls two lamps L1 and L2 in Fig. 2. The lamp L1 indicates that the program allows a writing operation and the other lamp L2 indicates that a button selection operation is required by the program. As shown in Fig. 1, a digital signal is fed into a digital signal to frequency converter (D/F converter) [7] from the NEAC-L3 computer, which generates a lamp control signal. The signal is transmitted to a remote terminal and drives two relays in a tele-writer receiver, in order to switch on or off the lamps L1 and L2.

2.2 *Operation and Software*

Characters are drawn on a sheet of paper in the drawing surface of the input device with a transmission pen as shown in Fig. 2. There is a "FEED" button on the upper left corner of the drawing area to feed paper. Besides the FEED button, 4 control buttons marked B1, B2, B3, and B4 respectively are provided at corners and at an edge. These buttons are monitored by a software program and are used for various functions according to program context.

It is necessary for the recognition program to detect completion of one character. The scheme employs explicit signalling by a user in order to ensure the detection. The user moves the pen tip to control button B1 everytime he completes a character and further to control button B2 when he completes a number of characters which he wants to be recognized by the recognition program. Then the program starts to recognize characters one by one and outputs names of characters, their sizes, and positions into an output buffer memory.

The number of characters recognized at one time is limited by a size of a buffer memory and is 9 characters at the present moment. A total of 86 characters, that is Katakana (a set of Japanese phonetic symbols), numerals, and symbols $+$, $-$, $\times$, $\div$, and $=$ can be recognized. For recognition, a character whose size ranges from 8 mm square to a full size may be positioned at any place within the writing area.

A sequence of points input into the computer is smoothed at first by averaging technique used by Groner [2]. From this sequence of smoothed points, a segmented pattern is extracted by a method of Bernstein [1] which approximates the original input pattern by pieces of straight lines. An example is shown in Fig. 3. In Fig. 3, segmented patterns are shown below with corresponding input patterns. This segmented pattern is expressed in a form of a bi-directionally linked linear list which consists of segment blocks and disconnection blocks.

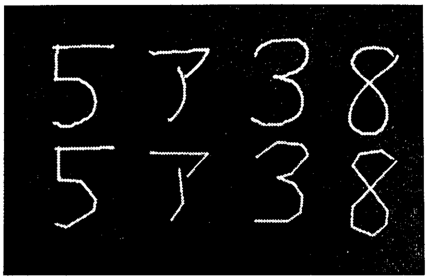

Fig. 3. Input patterns and their corresponding patterns (below).

A segment block corresponds to a straight line and a disconnection block corresponds to a part where the pen is up in one pattern.

When the user signals the completion of a group of characters by moving the pen tip to button B2, the recognition program starts to process each data list. First of all, the recognition program calculates the total length of drawn lines, normalizes segments and disconnections by the total length, and records relative lengths in corresponding blocks. Those segment blocks having a relative length of less than 2 percent and being located at the top or the end of the list are removed from the list as a noisy component. Next, those consecutive segments which represent connected part in the modified list of the input pattern are grouped into a stroke. The number of strokes in a list of a character is counted. For example, "2" has 1 stroke, "ア" has 2 strokes, and "ホ" has 4 strokes. From the list, features of the pattern are extracted and making use of those features, a program recognizes the pattern as one of possible characters on a tree-like decision logic which has been heuristically built and improved by a human designer.

The recognition program was written in an assembly language and has a size of 8 Kwords without working storage. Ten subjects who were given instructions on how to print such similar Katakana-numeral, Katakana-symbol, or Katakana-Katakana pair as (ク, 7), (ノ, 1), (ニ, =), (メ, ×), (ソ, リ), and (ナ, +), printed a total of 860 characters. About 95% of them was correctly recognized at the first trial. Time required for recognition process was about 1.3 seconds for the maximum 9 characters.

3. *A Test from a Remote Terminal*

An evaluation test from a remote terminal was carried out by the CRIAR system. The CRIAR system is a man-machine communication system which inputs character strings by means of the recognition of hand-printed Katakana and numerals, processes them in a computer, and arranges appropriate messages in a synthesized speech.

A synthesized speech is generated by a terminal-analog type speech synthesizer controlled by the NEAC-L3 computer [8], [9] as shown in Fig. 1. The CRIARS application program includes a conversational one which quizzes in a synthesized speech and gives related comments for the answer proposed to the machine as a character string drawn on a graphic input device.

A graphic input device, an amplifier, and a loud speaker were set at a point about 10 kilometers away from the computer and both terminal equipments and the computer were connected by exclusive commercial telephone lines. It was found that no harmful noise existed and that there was no appreciable difference between a local reception and a reception from a remote terminal connected by a line. The use of the computer from a remote terminal was done more than 50 hours by more than 30 persons including many who had no experience before with the system. The character recognition performance was good and no bad effect was caused by a long distance transmission.

Because the CRIAR system program has a size of 17 Kwords excluding working memories, the program is divided into smaller units which are usually stored in a magnetic drum and are overlayed on a core memory when required. There was a possibility that a too long time was required before a response was obtained from the system after an action had been taken. The longest time was about 4 seconds which was required for a pair of character recognition and an audio response. A tempo of a communication between man and the computer was moderate but not uncomfortably slow.

4. *Conclusions*

A realtime character recognition was demonstrated from a simple remote terminal device about 10 kilometers away from a computer connected by an exclusive telephone line and a feasibility of such a man-machine communication system was shown. Moreover, the realtime character recognition scheme was combined with an audio response system into CRIARS which recognizes on line hand-printed characters and responses in synthesized speech. A conventional tele-writer was used as a graphic input device and was found to be practical. This tele-writer is inexpensive and has an advantage of economy.

It is necessary, however, to improve further recognition capabilities and to make an operation easier by developing a program which automatically detects a completion of character and making a user free from an explicit signalling of the character completion. The present software system may be thought to be at a simulation stage and it is necessary to replace the preprocessing part by a hardware, to allow the system having multiple terminals, and to improve economy These are problems remain to be solved in future.

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