SOFT DISPLAY KEY FOR KANJI INPUT

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Abstract. The concept of a soft display key as applied to input of large character sets or vocabularies such as Kanji, the ancient Chinese ideographic script is discussed. The Japanese orthography and the necessity of using Kanji characters in data terminals are explained. Problems arising from the number and complexity of Kanji symbols for the manufacture and use of keyboard devices are stated. A review is made of devices and methods presently used or suggested. The feasibility of the soft display key is then demonstrated. Some requirements for the design and implementation of a soft display keyboard for Kanji are considered. In conclusion, implications to man/computer interface design, human factors engineering and hardware unification and standardization are stated.

Keywords. Display key, soft panel, touch display, character set, Kanji input, programmed interface, data terminal, man/computer dialogue, human factors, cultural variation.

Introduction

The Kanji Script. The Ancient Chinese ideographic writing system, Kanji, is today used in China, Japan and to some extent in Korea. A principal advantage of an ideographic script is that its understanding does not suppose knowledge of the spoken language. Written Chinese, e.g., is understood all over the country, though the spoken languages are mutually incomprehensible /1/. The main disadvantages are obviously the large number and graphical complexity of written characters and the consequent hardship of learning and writing them. Once learned, reading, instead, does not present equal difficulty thanks to the excellent pattern recognition ability of man. Complex meanings are conveyed in condenced graphical patterns, which are grasped at a glance.

Kanji Data Terminals. The real prohibitions are, however, encountered in the design and manufacturing of typing machines and data terminals as well as in their operation. The man/computer interface is a serious bottleneck already with the European, modestly sized alphabet and keyboard. Particularly burning this problem is being felt in Japan, where the computer and information industries are now in full swing.

In the early beginning data processing in Japan was done on the basis of romaji, the European alphabet. In Japanese business and culture the Chinese Kanji and the Japanese Kana writing systems, however, play the main role. Therefore, in Japan there is no true solution to computerization without the use of Kanji /1/.

The demand for data terminals is increasing rapidly. For overcoming the technical, manufacturing and human factors problems involved in Kanji input a number of different approaches have been made or suggested. Several kinds of devices and systems based on very different principles are in use, while many have remained designs only. Some of these are reviewed below in order to get insight into the problem and the present situation.

A technique based on the display input principle is then introduced and suggested for coping with the Kanji input problem. The technique is demonstrated capable of entering all Kanji characters on a normal western size keyboard with normal size characters and operable by finger.

The Japanese Orthography

The Japanese orthography is rather complicated. Two kinds of script are used - the Kanji and the Kana. Kanji is the ancient pictographic writing system adopted from China about 1700 years ago. The Kanji characters used today are either original Chinese symbols or symbols later formed or modified in Japan.

The Kana Syllabaries. Kana is the Japanese phonemic writing system. It consists of two syllabic alphabets - Hiragana and Katakana. These are parallel character sets, consisting of 46 syllabic characters and two diacritics. Both Hiragana and Katakana denote the same set of syllables, but are used for different purposes. Their graphics have been derived from Kanji, but are considerably simpler. Particularly Hiragana has been strongly simplified into a kind of shorthand.

All three character sets are necessary by tradition. For Japanese words both Chinese characters and Hiragana are used. Hiragana is also used to form grammatical endings and other syntactic units to Kanji words, while loan words from foreign languages are usually transcribed in Katakana. In addition, Katakana is often used in polite addressing forms. The patterns of usage are not, however, well defined. Ever more often today one can see words of Chinese origin written in either Kanji or Kana or both intermixed.

Kanji Character Sets. Dictionaries of varying coverage in present day use record 49,964, 14,942, 9,921 and 3,885 Kanji characters respectively /2/. The number of characters sufficient for everyday use such as reading newspapers and magazines varies from 2000 to 3000. About 2000 characters have been designated as essential and selected as a standard set for publishing. A set of 881 characters is used in basic education and further a minimum of 1968 characters have been selected for educational purposes by the Japanese Ministry of Education /2/.

Despite the fairly large numbers of characters recorded in dictionaries, some 200 most frequently used Kanji account for over 50 per cent of the usage in text while 800 Kanji supplemented with 50 Hiragana already account for 90 per cent of ordinary text /3/.

The Inadequacy of Kana. For practical purposes such as typing, it would be desirable to be able to use the Kana syllabaries, since they can be managed with conventional keyboard techniques. But unfortunately the Kana systems are linguistically inadequate. The problem is polysemy. It is not uncommon that several Kanji characters with different meaning have equal or so similar pronunciation that they become identical in Kana. There are e.g. some 70 Kanji characters, which are pronounced and transcribed as "Shou" in Kana /4/. On the other hand many characters have become to denote concepts quite different from the original, which happened to have similar pronunciation /5/. Thus the phonetic and semantic inadequacies of the phonemic scripts necessitate the use of the old Kanji, which is unambiguous.

Problems with Kanji Input

The main problems of using Kanji are connected with the input devices. For output, a Kanji printer or display though more expensive than its European counterpart, can be realized by standard output technologies such as matrix printer and CRT display, see e.g. /2,4 and 6/. The character print head or display matrix only must have higher order to give the required graphical resolution. Kanji printers are available, which use print head dimensions of e.g. 15 by 18 or 22 by 24 dots.

But for input of Kanji characters we need a keyboard, which has a great many keys or some special arrangement by which all necessary characters can be entered. In fact, an equipment, which would allow to encode all Kanji characters would be simply absurd to implement and to operate by conventional keyboard techniques. In developing keyboards for typewriter, telex and data terminals it has been necessary to severely restrict and carefully select the set of characters to be included. Yet it has been necessary either to squeeze many characters per key or to reduce the key size so much that it can be operated only by a special implement. Despite this, sophisticated special techniques for input of nonstandard characters are necessary in many applications. Nonstandard characters do frequent in various texts and subject areas. The difficulty with them is not only that they are sometimes indispensable, but also that different sets of nonstandard characters are needed from one application to another.

Standard Data Processing Set. For the purposes of data processing the Information Processing Society of Japan has instituted a set of 6100 characters as a standard set /2/. These include the 1968 most common Kanji characters plus Hiragana and Katakana, a set of system oriented Kanji, a set of other system oriented symbols and the ordinary European alphanumerics /2/. Not all of these are, however, usually available on present devices. E.g. for the terminal described in /2/ the following sets have been selected:

Most often used Kanji	1,968
Kanji for general use	1,850)
Kanji for personal name	92)
Kanji for auxiliary use	26)
Additional Kanji	2,538
System oriented Kanji	64
System oriented symbol	95
Alphanumeric & symbol	94
Katakana & symbol	92
Hiragana & symbol	85
Total	4,936

In the Japanese card punch key entry device developed by IBM Japan and described in /3/ there are 2,304 characters. In order to make the keyboard manageable by the human operator, the size of keys must have been made very small. In the IBM equipment the key dimension is 4 mm. This has permitted to fit the keyboard on the table of a normal size card punch device.

Using such a keyboard does, however, cause considerable eye strain to the operator and requires a lot of hand transport. Moreover, special means of key actuation such as a stylus as in /3/ or a pantograph mechanism as in /2/ and /7/ must have been introduced.

Decomposition Schemes. Attempts have been made to develop rational decomposition schemes in order to break the characters down into simpler common elements. This would allow reduction of the keyboard size. The characters could then be piecewise reassembled by typing from their constituent components, see e.g. /8/. From technical viewpoint this approach would seem very advantageous. But, unfortunately there is little natural systematics and consistence in the graphical structure of the characters. Therefore any such scheme becomes artificial and difficult to use. In addition, such schemes are often insufficient of description and can sometimes specify only classes of characters.

Character Arrangement. Still another source of problems is the arrangement of characters on the keyboard. In Kanji there is little inherent systematics, which could be complied to. To minimize search time and hand or stylus transport, high frequency characters are often assigned to a central area. E.g. the keyboards described in /7/ and /15/ have used this principle.

One of the imperative factors in key arrangement is, however, the historical precedent /16/. In Japan this is determined by the Kanji Teletype, also referred to as Kantele, which has been used for thirty years in the newspaper industry /3/. Data input equipment usually conform to the phonetic order, which is generally used for typing machines. E.g. the equipment described in /7/ applies this arrangement.

Typing Speeds. Despite of the apparent difficulties, excellent typing performance can be achieved in Kanji input through practicing. The figures of words per minute and accuracy reported in /3/ correspond to those that can be observed on skilled western card punch operators. Thus, the enormous difference between character set size and the keying techniques in the two cultures causes little difference in the level of skilled performance /3/. The small size of characters causes, however, more eye strain to the operator and the large size of the keyboard more fatique to hand muscles on the Japanese equipment.

A Review of Techniques

An account of some techniques and existing devices for Kanji input is given in /4/. These and some others found in litterature are briefly reviewed here.

The Kanji Teletype. According to /4/ the Kanji Teletype (Kantele) is the most commonly used encoding equipment. Kantele has 192 keys, each of which bears labels of 13 Kanji characters. A shift key pad of 13 shift keys is used to select among the 13 characters on each input key. The number of keys has thus been reduced significantly, but there are still considerable drawbacks:

* The amount of hand transport and searching is still considerable
* The lack of logical arrangement plagues character localization
* There is no facility for either verification nor for nonstandard character input.

Operator performance observed with the shift key method seems to be inferior to methods using stylus.

A Chinese Typewriter System. In a Chinese Typewriter System abstracted in /9/, a keyboard is provided for quick access to a master file of digitized Kanji characters. On top of the keyboard is a character reference sheet, which is organized according to the order of the Chinese phonetic alphabet. By appropriate keying of a desired character, a mechanism within the control unit will access the master file. A graphic display is provided for verification of the entered characrter. Up to 9600 characters are available in the system.

The Sinotype System. This equipment is based on the principle of composing characters from a small set of strokes. There are 21 different elementary strokes from which each character can be constructed as a unique combination. An average of six strokes are required to form one character. The disadvantages are:

* The difficulty of decomposing characters into a set of strokes
* The difficulty of remembering the stroke combinations, which are different from the traditional calligraphy. A special combination dictionary must be used.

The Sinowriter System. In this system developed by IBM a Kanji character is formed from two parts, the upper and lower half. Both of these are classified using 36 standard subpatterns. These operations are, however, not sufficient to specify a character uniquely. A set of at most 16 characters are displayed on a CRT, from which the operator can then select the correct one. According to /4/ this system has been designed for foreigners, who do not understand Kanji!

A Kanji Data Terminal. In /2/ an input arrangement is described, which uses a printed character sheet and a superimposed binary code film sheet. A character is entered by moving a pantograph lever mechanism carrying a code reader device onto the selected character. On pushing a button the character code is flashed on a LED display and read from the film by an array of photo transistors.

This system allows to use two kinds of Kanji character boards with different character arrangements. The numbers of characters in the two sets are 2,205 (Onkun-jun) and 2,940 (Bushu-Kakusu-jun) respectively.

The Rand Tablet. This is a general purpose graphic input device developed by the Rand Corp. The system for Kanji input allows hand written stroke sequences to be drawn on the Tablet, matched with a pattern dictionary and displayed on a CRT. The disadvantages are:

* The slow speed, the amount of manual effort and difficulty of correctly drawing a character
* The complexity and inadequacy of pattern matching procedures.

Machine recognition of Kanji is not a solution to on-line Kanji input, because the human effort required to handwrite a character is considerably greater than the effort required to read it on the keyboard and to type it. If this, as it is, the case with the Roman letters and the Arabic numbers, then let alone with Kanji, whose calligraphy is work of art.

A Pattern Structural Coding Method. In /8/ a method is described, which enables generative description and definition of Kanji like patterns. The method allows systematic encoding of an unlimited set of patterns in terms of a small number of alphanumerically coded strokes and concatenation operators. Disadvantages of this method are:

* The need of long alphanumeric code strings for characters
* Insufficiency of the coding system to express unique stroke variations.

Automatic Phonetic to Kanji Conversion. Several systems have been developed for automatic conversion of phonemic Kana script into Kanji. These systems must rely on methods of grammatical analysis of the phonemic script. Reference files are necessary for the solution of ambiquities. The disadvantages are:

* The need of complicated natural language syntax analysis algorithms and large reference files

* The inadequacy of the algoritms as to correctness of translation.

Bunkai-Hatsuon Conversion Method. The subject of /4/ is also a conversion method from phonemic script to Kanji. It makes use of the fact that many Kanji characters have several pronunciations. These can be used to reduce the ambiquity in mapping phonemic script to Kanji. The method is called Bunkai-Hatsuon.

Tests and comparisons reported in /4/ indicate that on the average four key strokes are adequate to uniquely identify a Kanji character as opposed to six strokes with the Sinotype. Input rates of 40 to 50 characters per minute have been achieved. According to the authors this is not fast enough for all purposes, but it satisfies the requirements for some man/computer communication needs and comes close to an "easy to use" system. An advantage of this system is that it can be used for any size of character sets. The only modification required is t(add the new Kanji characters to the system dictionary. The system requires an advanced computer system for its support (Tosbac 3400).

A Kanji Input System. A Kanji keyboard has been developed in /7/, which enables incorporation of nonstandard characters as well. The keyboard has in addition to the standard keyboard three special sections. These are called Spare Area, Function Input and Pattern Input sections.

On the Spare Area different sets of characters can be provided by using replaceable character sheets and function keys for sheet identification. Customized character sets can be defined for varying applications.

The Pattern Input section enables introduction of new characters to the system. Character patterns can be interactively constructed from strokes using stylus and a 64 by 64 point grid. The generated patterns are added to the repertoire of nonstandard patterns and assigned with a sheet number and key position. The defined character pattern is then hand printed on the specified position of the sheet to enable selection. When entered, any character can be displayed for verification by the operator.

In principle the system can handle an unlimited number of Kanji characters, but its operation is obviously quite impractical. In addition it also requires a considerable computer system (NEAC 2200/200) for its support.

The method described above is in principle similar to that used in some programmable terminals and pocket calculators, in which the user can define various functions, assign them to special function keys and label them by handprinting on overlay sheets accordingly. This comes close to the idea of a programmable display key, in which not only the function, but also its label is stored in the memory and displayed to the user for reference at program control.

The Soft Display Key Principle

We now confine ourselves to suggesting a method for Kanji input, which is based on the programmable display key concept. The display key, also referred to as videoclavis in /11/ - can be thought of as a normal input key, but with the difference that its key top caption, instead of being engraved, painted or otherwise made and fixed permanently on the key, is now generated by a display component under program control. The character images are stored in memory, either read only or renewable, and presented to the user for reference as appropriate. At any system state only a relevant set of symbols or words are displayed as a menu. At the touch of a display key, the whole setup, some part of it or nothing at all may change according to how that step had been programmed.

Though simple in principle this is a brave idea promising to upset present conceptions about keyboard and panel arrangements as well as the principles of man/computer interface design.

Conceptually the soft display key

is related to the touch sensitive screen /10/. The latter makes the display screen also an input device, while the former makes the keyboard also an output device. Both allow to improve the man/computer interaction by offering a fully virtual human interface.

As applied to Kanji input, the main advantage of the virtual interface is that the keyboard equipment becomes independent of the size of the character set. Consequently the size of the keyboard can be reduced to what is considered most suitable from operating and manufacturing points of view.

In addition, the very same keyboard can be equally well used for Hiragana, Katakana, Latin, Cyrillic or whatever character set is needed. Very large character sets such as Kanji, must be structured in some way so as to allow quick access to the aimed character. This can be done by breaking the set down into subsets by an appropriate scheme. Features such as subarea on a traditional keyboard, phonetic order, stroke number, radical component, writing sequence, grammatical or semantic category or perhaps still other characteristics, which a European, only superficially familiar with Kanji, cannot imagine of.

A tree like access structure with equally sized and appropriately named subdirectories would guarantee most efficient access path. Actual characteristics of Kanji and learned conventions may suggest differences to obtain a most practical access scheme.

The input display principle is a very general idea and its essential functions can be realized by using alternative technologies available for display and sensing. Similarly both hardware and software support systems allow great freedom of design decision.

Display technologies are becoming available, which allow fabrication of composite matrix element display structures sufficient for the resolution required by Kanji. The display component may be based on light emitting diode (LED), liquid chrystal display (LCD), electroluminence (EL) or other flat panel display technology.

Various technologies are also available for implementation of the switching field necessary for sensing the presence of a finger on some display area. The switching function can be based on contactive, capacitive or resistive effect, photo detection, acustic signal etc. switching components.

The switching system can either be integrated into the display system or overlaid to it. On the panel side the two systems are, however, independent of each other. They are only coordinated with each other with respect to location. On the system side they are associated with each other under common program control.

The discussion of both technical design objectives as well as specific applications would, however, involve expert knowhow of both display electronics as well as Kanji script, the Japanese language, type of application, user environment etc that we do not possess. Their discusssion must therefore lie outside of the scope of this paper. The aim of this talk has only been to demonstrate the feasibility of the idea and to point out some of its implications.

Some Implications

A number of key problems involved in Kanji input devices and their use seem to find their solution in the soft display key input principle. The major problems solved and advantages achieved are as follows:

* The number of keys and the size of the keyboard can be reduced to what is considered normal

* Yet normal key and character size can be maintained for good legibility and convenient operation

* An unlimited number of Kanji characters can be accommodated

* New characters can be added by definition as necessary

* The character set can be adapted or changed from one application to another

* The character layout can be changed from one convention to another according to user skill

* The same keyboard can be used for Kana, ASCII and still other character sets when necessary at the same time

* The keyboard can also be used for user interaction such as prompting, indication, etc

* Moving mechanical parts can be fully eliminated and all keys can be made identical to allow cost efficient mass production.

Optimal Key and Keyboard Size. The keyboard can be designed into optimal size from manufacturing and human factors points of view. Yet the key and character size can be made large enough for good legibility and convenient actuation by bare finger.

The need for special arrangements for nonstandard characters and verification of entered characters becomes unnecessary.

Virtual Character Sets. Through menu structuring and paging an unlimited number of characters can be supported independently of the number of physical display key fields. It becomes possible to use different size keyboards for a given character set and different character sets for a given size keyboard. The only limiting factors are memory space and display raster resolution. New characters can be added to the system by programmed definition or by loading from external media.

Portability and Adaptability. Software portability and adaptability are qualities, which reflect the ease of moving programs from one hardware environment to another and modifying them to fit different objectives /15/. The programmed key labelling principle allows these qualities to be extended to the man/computer interface.

Character set device independence provides for a capability, which can be called human interface portability. This means that a character set layout and menu structure can be transferred from one keyboard to another simply as a software copy. If not directly compatible, the conversion can be made on software level. This quality does contribute to reduced need of operator retraining and higher equipment usability.

Adaptability. The need for adaptability emerges from system dependence on the application and user environment. System adaptability reduces this dependence and extends the scope of potential system application. The display key concept does not eliminate variation or incompatibility among different application or user environments, but it allows the system user interface to be adapted to and complied with the different conventions and requitements by modification and adjustment of the software. Even minor operator preferences and habituations can be accommodated easily. In many application environments considerable savings could be achieved, if customization and development could be further done by the user along with his developing experience. The virtual interface does allow such development.

Unified Hardware. In spite of all the flexibility and variation it is possible to develop unified display key component designs and to standardize the panel and keyboard structures for cost effective mass production.

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