Hand-Print Recognition Technology for Construction Monitoring

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ABSTRACT

An important incentive for achieving project information intergration is the input of high volumes of data efficiently and accurately. The construction industry is characterised by high volumes of data. Computers can now handle this data volume comparatively cheaply and thus, potentially, offer many advantages provided certain basic requirements are met. These basic requirements can be summarised as 'single-pass' input with concurrent validation. This resulting combination should eliminate further data transposition and the inevitable accompanying error rates. One such approach uses hand-print recognition (HPR) technology, which can be used to produce an electronic copy of data created during the common human task of hand-writing various documents for project information purposes. The security and need of 'hard-copy' can be satisfied without further resources to create an electronic copy. For such as site monitoring, an independent HPR terminal would offer further advantages for data collection. The paper discusses a prototype battery powered HPR terminal developed at Aston University, that offers day-long performance for construction site monitoring. Discussion on the prototype includes the application of 'micro-chips' for the intermediate storage of data prior to later connection with a computer for future processing, and also current field trials.

Technologie de Reconnaissance de Signes Calligraphiques pour le Contrôle sur Chantier

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MOTS-CLÉS

Contrôle sur Chantier, Rassemblement Performant de Donnees, Reconnaissance de Signes Calligraphiques.

SOMMAIRE

Un objectif important de la réalisation de l'intérgration de l'information du project est l'introduction d'un volume élevé de donnees de menière performante et précise. L'industrie de la construction se caractérise par un volume élevé de données. Les ordinateurs peuvent à présent manipuler ce volume de données pour un coût comparativement peu élevé et ainsi offront un potential d'avantages à condition que certaines exigences de base soient respectées. On peut résumer ces exigences à l'introduction à passage unique ("single pass") avec validation simultanée. Cette combinaison devrait éliminer d'autres transposition de données et les taux d'erreurs inevitables qui les accompagnement. Une telle approche utilise la technologie de la reconnaissance designes calligraphiques (HPR), qui peut être utilisée afin de produire une copie electronique de données crée lors de la tâche humaine simple qui consiste en l'écriture à la main de différents documents dans le but d'information du projet. Les problèmes de la sécurité et du besoin d'une copie sur support papier peuvant être résolus sans ressources supplimentaries afin de crier une copie électronique. Par example, dans le cas du contrôle sur chantier un terminal indépendant de HPR affrirait d'autres avantages pour la collecte des données. Cet article traite d'un terminal HPR prototype fonctionnent sur batterie, mis au point à l'Université d'Aston, et qui offre une performance continue pour le contrôle sur chantier. Le rapport sur le prototype comprendra une application des "puces" pour le strokage intermédiaire de données préalables à la dernière connexion avec un ordinateur pour traitement futur et incluera aussi les essais d'installations conduits en ce moment.

INTRODUCTION

In all countries there is a continuing need to improve performance through developments in design and construction. I use the word performance in preference to productivity, with which it may be regarded as synonomous. The evidence from some previous research [1] confirms this need for performance improvement. An important incentive to achieve change must be through project information integration. To some extent by proportion, all projects produce large volumes of data. The same is so for monitoring of construction. Monitoring is most important when comparing 'plans to reality' in order to achieve proper project control and in providing 'feedback' for further design and construction development.

It is now well recognised that computers can handle large volumes of data. A computer supported classification system can integrate project information and include monitoring data. Provided all the data is collected and entered in the form of computer files that are inter-related, then free sortations of the data are possible, for example, within and between projects or between monitoring data and normal project information. Clearly, there are significant resource implications in rationalising project information in this way. Significant resources are quite commonly applied, but how productively are they used? Clearly, the most productive data collection methods are necessary. What are the basic requirements for high performance in data collection?

SINGLE-PASS INPUT

The aim must be to collect appropriate data at the least cost. Bona fide data is created at many points in the normal design and construction process. A magnetic copy of all this data is required for current and post project computer processing. As in the design and construction process, there is a need for high performance in the accompanying data collection process. The best performance is likely to be achieved by applying what can be summarised as 'single-pass' data entry.

A variety of devices can link with possible human data input methods to create a data file in magnetic form. The most common human method of communication remains as alpha and and numeric characters created on paper. A device which can recognise hand-written alpha and numeric characters can create a magnetic copy of data normally associated with paper transactions. For example, invoices covering material deliveries to a construction project or a reliable 'background' copy of the monitoring data collected for a research project. In creating appropriate data files by single-pass entry, it is essential that the data is validated at the same time.

INPUT VALIDATION

It is usually appropriate and most reliable if input data is validated at the time of entry by originator. Wide experience has shown that subsequent transposition stages tend to introduce errors and this progressively degrades the quality of the data. To optimise data collection performance, validation must be integrated with single-pass entry. An important element in this integration, available on some devices in varying degrees of

sophistication, is a form of display of the magnetic copy of the data being entered. As a common denominator, this allows the originator to check the data entered line by line during the input stage. This 'added routine' to the data collection is important to attain quality and accuracy in the files formed. There is no substitute to a process of endeavouring to attain 'good' data. The output will only ever be as good as the input.

Clearly, software can be used in association with the input stage to prompt the responses of the originator. This can aid the quality and accuracy of the data collected. A simple example would be automated checking routines for spelling errors in large text entries. The main purpose behind an insistence for single-pass and concurrent validation of data entered in appropriate files is to avoid the resource waste and data quality losses associated with following data transposition stages, which are currently all too common.

DATA TRANSPOSITION

Data transposition is a common aspect of data handling. A time delay in transposing data is inevitable. It is computers that have so reduced this activity. By manual means, significant data volume transposition without loss of quality is practically not possible. It is computers that commonly achieve perfect data transposition. Any manual transposition increases resource needs. It is computers that require minimal additional resources to achieve similar data transfers. By manual means, data transposition to a 'good' standard only can be difficult to achieve. Significant data quality losses are common i.e. of the order of 20 percent, for example. To recover such as this loss level, if it is possible at all, further resources are needed to filter the data to achieve it.

These well known difficulties in data handling reinforce the potential of computer support in project information integration. The conclusion must be that single-pass data entry with concurrent data validation is in many ways preferrable to any unnecessary transposition by manual means. As in the construction of a project, it is essential to eliminate 'repeat work' and the repeats of repeat work that inevitably reduce the quality of the product - and for data, in the easily realisable ways they can be used.

RECENT TECHNOLOGY

A device formed on recent hand-print recognition (HPR) technology can provide a single-pass and validated data entry capability. The specific HPR device discussed in this paper is called Micropad, which was originally designed and produced by Quest Automation of Dorset, England. The Micropad is able to recognise the full set of alpha and numeric characters. Some additional puntuation and other marks are also recognised. The writing surface which accepts the hand-written characters is basically a pressure sensitive surface. For recognition of an approved character, the human hand must press (without undue pressure) the appropriate character pattern on to the surface.

The Micropad product was developed by Quest Automation from work done by the British National Physical Laboratory (NPL). The NPL created a sophisticated software system, to operate with the pressure sensitive surface, that could

perform reliable pattern recognition. This system was offered by NPL for commercial development and exploitation. The Micropad device was designed for use on the desktop, to be mains powered and normally operated in direct contact with a host computer through an RS232 connection.

HUMAN INPUT

The HPR technology can interface well with the common human ability to write characters. The character string can be observed in the normal way, which aids data entry i.e. the formation of sentences and similar contexts. The technology assumes a normal hand pressure pattern in forming characters. No special requirements are needed. As an example of a character pattern, the letter A would be recognised as made from the connected strokes /\ - , in that order and in the normal realtionship to each other. In practice, most people can achieve a better than 95 percent recognition rate in less than six hours. Incorrect character entries can be over-written to produce the correct character. Most characters are corrected at this second attempt. In addition, an inverted U can be used to over-write a character to cancel it i.e. to return as a space in the data entry record.

On the Micropad, validation of character entries is achieved by observing the concurrent 'line display' of the line being entered. This line can be corrected at any time, usually on the completion of each line i.e. line by line during the completion of a page of data on the pressure sensitive writing surface. Thus, validation can be achieved at the time of entry. This is a most important attribute for high performance in data collection. The HPR approach can also be classed as a 'user' orientated alternative in data collection.

HARD-COPY ALTERNATIVE

Paper is important in many data transactions as a reliable record. This is likely to continue into the foreseable future. Paper is appropriate in many contexts, if only because it is renewable and thus a generally available material that is suitable for record purposes. In research, where accuracy and completeness are most important, security in the data collected is vital. On paper, the research data can be stored in case of computer processing problems.

In many contexts, a paper and a magnetic copy of data will be needed currently for many reasons, for example, appropriateness at the collection stage or for 'background' security of the unique record. In encouraging development using computers, a paper approach is orientated to a familiar human method, i.e. hand-writing, and is based on the most common form of human communication. Using other words, current practices involving paper can be enhanced by HPR devices in order to easily create computer data files. The every day formation of these files is vital to development. Rationalisation of these files can more easily lead to information integration - so necessary in project information to improve performance.

AN INDEPENDENT HPR DEVICE

For many applications, the independent use of an HPR device would be

advantageous. For construction site monitoring this attribute is essential. Achieving this necessary independence was the main reason behind developing such an HPR prototype at Aston University. For research involving site monitoring, the freedom to move from operation to operation is required i.e. from one workplace to another on the site. Ideally, this should be possible without restriction caused by the data collection equipment. This complete independence of equipment operation during normal site working hours could only be achieved by battery power support carried by the observer. In the most difficult situations, no site based power supply could be anticipated. In which case, the battery support must provide day long performance as an essential requirement. This was achieved in the HPR prototype developed at Aston University, that is described in this paper.

The prototype contains a set of four re-chargeable batteries of different sizes, each one dedicated to support certain power requirements. The batteries can be re-charged overnight, in the normal way, to provide power for the next day. Battery weight, based on the best of current technology, was an important determinant in the design. For this reason the prototype was developed as two parts; a Micropad and portable case for independent use, and a separate mains powered system to transfer data from temporary to permanent storage.

PORTABLE CASE AND MICROPAD

A standard 'off-the-shelf' Micropad HPR device was used in the prototype. The Micropad has a pressure sensitive writing surface and a line display for entry validation. This device originally designed for the desk-top is accompanied by a case and contents that include the necessary batteries. In use, the case can be carried by hand or mounted on a back-pack frame to allow both hands to be used to handle and operate the Micropad writing surface. Including the batteries, the portable case and Micropad weigh approximately 10 kilogramms i.e. about 22.5 lbs. Besides the batteries, the case contains a processor to transfer data from the Micropad buffer to storage within the case. This storage device is a 16K capacity RAM-pack. The data transfer from the Micropad to RAM-pack is done line by line, or by complete page, from the Micropad storage buffer. The RAM-pack is provided with a small re-chargeable battery which will maintain the stored data for between 10-14 days.

On completion of a data store, the RAM-pack can be simply disconnected (standard 25 pin plug) from the case and posted in appropriate packing, or hand delivered, to the site of the other part of the system. This remaining part of the prototype is mains powered and is used to convert the data stored on a 16 RAM-pack to a computer standard DC 100 cassette tape. This form of tape is small and robust. They too can be posted, for example, to the office where a host computer can process the serial line of data they contain.

MAINS POWERED SYSTEM

This part of the system involved the selection of an off-the-shelf assembly of common components to provide a tool for the development of the prototype. The selection includes an industry wide low-cost data storage medium i.e. the DC 100 cassette tape. These tapes are accommodated in a DEC TU58 dual drive

unit, which can be rack-mounted to pass data to various DEC mini-computers or other host machines which have small tape reading facilities. Within this development system, a link is made between the RAM-pack and the TU58 by an AIM 65 (Rockwell) development micro-computer. This machine uses proven 6502 chip technology which was inexpensive and easily available during the development period.

The AIM 65 is now dedicated to transferring data from a RAM-pack to the DEC TU58. A small roll-printer on the AIM 65 can be used to establish correct data transfer by taking samples. This mains system would generally be used to transfer the data from monitoring during a day, as one single transfer to a DC 100 tape. The DC 100 cassette tape design is stable and robust in construction. This means that any cassette tape can be posted without hazard to the stored data, and background copies can be easily created.

FIELD TRIALS

The portable and independently powered Micropad prototype can be used by an 'observer' in an active construction site context. The writing surface can be used 'free format' to enter any alpha and numeric characters. For site monitoring, this means that an 'open' approach can be taken to the data collected and thus, it does not confine the observer to a purely pre-determined form, or expected subject, of data input. In a current application, the prototype can collect 'activity sampling' data, in which the observer uses codes to describe the work under observation, in order to obtain a quantitative measure of input manhours. At the same time, the observer can also use the prototype to collect a 'diary of events' i.e. a related text element of data that uses rationalised natural language. Using part activity sampling code allied to these text entries, it is possible to integrate the quantitative activity sampling data with this text record, as a necessary balance of qualitative data. This need for qualitative data is discussed in more detail in a paper [2] presented at the W55 Building Economics Symposium in Ottawa, July 1984.

In a specific application context, the prototype applies the quantitative and qualitative data collection methods described in a design and construction research project at Aston University. The project concentrates on private sector house building and is being done in collaboration with the Cement and Concrete Association, who have a keen interest in developing house building performance [3] i.e. in improving productivity standards. This is the important sector in United Kingdom new house construction, as it is currently responsible for 85 percent of production.

The data generated from the monitoring of current new house construction can be used to create 'informed' feedback. This feedback can be used in design to faciliate construction, while retaining control over the quality of the product intended. Also, this feedback can be used in construction, specifically to improve the construction process. The aim is to improve performance on a cyclical basis i.e. from design to construction, including monitoring, to feedback and back to design again.

CONCLUSIONS

The HPR prototype described in this paper has certain attributes which can improve the performance, i.e. the productivity, of data collection in various contexts. These main attributes are as follows.

1. The device provides for a free format of hand-written alpha and numeric characters during data collection i.e. normal flexibility.

2. The entered data can be validated by the orginator at the time it is created.

3. A magnetic copy of the data is immediately available after entry, and so no further, wasteful and error prone, transposition is necessary.

4. The hand-written input provides a 'hard-copy' of the data collected as 'the original' for security purposes; for example, a unique record in a research project.

5. The prototype provides the additional benefit of complete independence in operation, based on 'built-in' re-chargeable battery power.

6. This independence could be further enhanced by developments in the hardware, the software developed to manage such a device, the possible reductions in power requirements and improvements in battery technology i.e. all contributing to substantial reductions in battery weight.

A prototype of the kind described in this paper illustrates a new era in which a wide range of 'bespoke' machines may be developed for specific applications i.e. often with only small production runs. It is an example among many terminals which could be designed for specific purposes within the construction industry. Clearly, we need many such devices to assist in site monitoring, and in other areas, to improve on the current low standards of productivity. In a current application at Aston University, the HPR prototype device can provide data promtly and accurately from the site, for immediate analysis to form feedback for design and construction research and development. Only on the basis of good feedback we can reliably develop design and construction standards and thus improve construction performance i.e. productivity. In order to achieve more of what we need, we must concentrate on whatever means assist in rationalising the construction process and not the design alone. We must preserve quality, while attaining greater quantity from the limited resources available.

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